ENERGY EFFICIENCY IN THE SOUTH

Appendices

Appendix A: Federal Policies, Programs and Measures to Promote Energy Efficiency in U.S. Buildings and Industry

Numerous federal deployment activities seek to improve the efficient use of energy in the United States. A database of these and other climate change mitigation policies and measures was recently compiled for the U.S. Department of Energy (CCCSTI, 2009). The database includes hundreds of policies and measures that promote energy efficiency improvements, including those directed at residential and commercial buildings as well as industry. This appendix provides a brief overview of these federal energy efficiency deployment activities, as a means of understanding the niche filled by the initiatives described in *Energy Efficiency in the South*.

Appendix A.1 Federal Programs and Measures to Promote Energy Efficiency in Buildings

A total of 124 Federal policies, programs, and measures are currently in place to encourage more efficient use of energy in buildings. Most prominent among these Federal deployment activities are a range of labeling and information dissemination programs such as the ENERGY STAR program—run jointly by EPA and DOE—which is arguably one of the most successful energy information programs in operation in the United States. The ENERGY STAR program was introduced by EPA in 1992 to fill the information gap that hinders market penetration of energy-efficient products and practices, and to enable businesses, organizations and consumers to realize the cost savings and environmental benefits of energy efficiency. Its market-based approach involves four parts: (1) using the ENERGY STAR label to clearly identify which products, practices, new homes, and buildings are energy efficient; (2) empowering decision-makers by making them aware of the benefit of products, homes, and buildings that qualify for ENERGY STAR by providing energy performance assessment tools and project guidelines for efficiency improvements; (3) helping retail and service companies in the delivery chain to easily offer energy-efficient products and services; and (4) partnering with allied programs to leverage national resources and maximize impacts.

There are also 20 or more Federal activities targeting energy efficiency in buildings that involve coalitions and partnerships; tax policy and other financial incentives; education, training, and workforce development; and market conditioning. Among the ten policies and measures addressing building codes and standards are two programs of particular relevance to the initiatives proposed by *Energy Efficiency in the South:*

- *Federal* appliance and equipment standards require minimum efficiencies to be met by all regulated products sold; they thereby eliminate the least efficient products from the market. First introduced in California in the 1970s, the state's efficiency standards were followed a decade later by federal standards implemented through the National Appliance Energy Conservation Act in 1987. By the end of 2001, federal standards were in effect for more than a dozen residential appliances, as well as for a number of commercial sector products.

With passage of the 2005 Energy Policy Act, new efficiency standards were legislated for 12 residential and 5 commercial products.

- The Building Codes Assistance Program (BCAP) established in 1994, is a joint initiative of the Alliance to Save Energy, the American Council for an Energy-Efficient Economy (ACEEE), and the Natural Resources Defense Council and partly funded by DOE. BCAP provides custom-tailored assistance on building energy code adoption and implementation to assist State and local regulatory and legislative bodies and help coordinate others representing environmental interests, consumers, labor, and industry. BCAP provides States with code advocacy assistance, and coordinates with DOE to provide technical assistance.

Relevant Federal policies also include power rates offered by the Bonneville Power Administration, Tennessee Valley Authority and other federal power producers that typically do not pass along real-time power prices to residential consumers. In addition the federal government influences mortgage interest tax deductions that encourage increased home sizes; energy-efficient and location-efficient mortgages are available in many places, but their usage is quite limited.

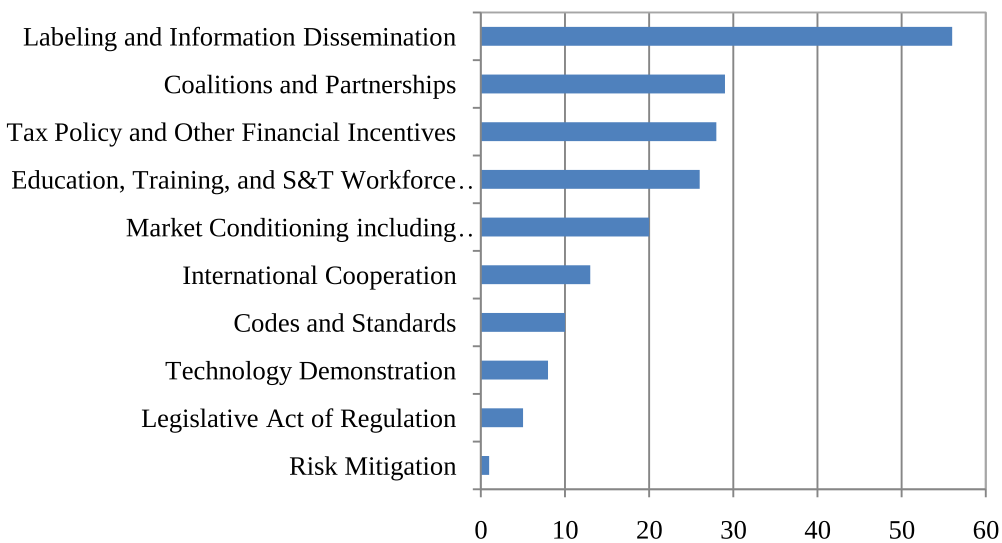

Figure A.1 Federal Programs and Measures to Promote Energy Efficiency in Buildings

Note: Some activities fit into more than one category, so the total count exceeds the total number of identified deployment activities addressing buildings.

Source: CCTP/Energetics Deployment Inventory Database dated June 5, 2009

Appendix A.2 Programs and Measures to Promote Energy Efficiency in Industry

A total of 72 policies and measures promote more efficient use of energy in industry (see Figure A.2). Remedying a lack of specialized knowledge and addressing incomplete and imperfect knowledge barriers are high priorities in the U.S. and are politically achievable approaches in the U.S. context. As a result, "Labeling and information dissemination" are the most common type of deployment program targeting industrial energy efficiency (Figure A.2).

Numerous public-private partnerships with industry exist, such as Save Energy Now, administered through the Department of Energy's Industrial Technologies Program. SEN work with large industrial partners in energy-intensive industries to identify areas of significant efficiency gains. Save Energy Now recognizes industrial energy efficiency leaders and works through the supply chain as well.

The Industrial Technologies Program also works with small and medium-sized firms through the audits performed by the Industrial Assessment Centers at universities throughout the country. This program identifies cost-effective opportunities for energy efficiency throughout the firms' operations. Unfortunately, implementation of these recommendations was only 47% from program initiation in 1981 through 2007 (DOE, 2007), suggesting that significant benefits are not being captured.

Another public-private partnership in the U.S. couples the government with manufacturers to reduce energy intensity by 2.5% or more per year. This is done through energy management standards, which almost always include a comprehensive energy plan and an energy manager to oversee the implementation of the plan. This type of project ensures that equipment continues to operate as efficiently as possible, as energy use is constantly monitored.

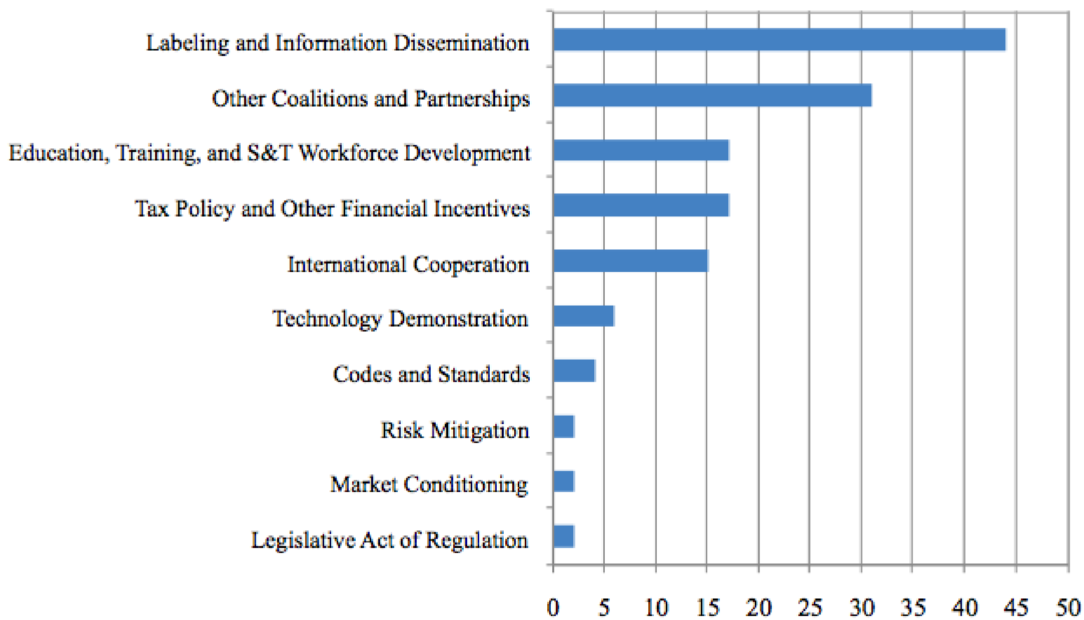

Figure A.2 Federal Programs and Measures to Promote Energy Efficiency in Industry

Note: Some activities fit into more than one category, so the total count exceeds the total number of identified deployment activities addressing industry.

Source: CCTP/Energetics Deployment Inventory Database dated June 5, 2009

Appendix B: Supplemental Background on Modeling Methodology

In the Carbon-Constrained Future (CCF) scenario, a carbon price is added to each ton of carbon dioxide, starting at $15 per ton in 2012 and growing annually at 7%. Allowances are redistributed to load serving entities as described in the following table. There are no carbon offsets.

Table B.1 Allowance to Local Distribution Company (LDC)

Year	Allowances to LDC
2013	34%
2014	33%
2015	33%
2016	33%
2017	33%
2018	32%
2019	31%
2020	31%
2021	30%
2022	29%
2023	28%
2024	27%
2025	26%
2026	26%
2027	20%
2028	15%
2029	10%
2030	5%

Appendix B.1 Calculating Water Conservation from Energy Efficiency

Using the energy-efficiency potential outlined in this study, we project the decrease in freshwater consumption for the cooling of conventional and nuclear thermoelectric power-plants in three NERC regions: SERC (Southeast), FRCC (Florida) and TRE (Texas).

Using data from the Electric Power Research Institute, we estimate average water consumption in gallons per megawatt hour based on plant and cooling system type (Table B.2).

We also assume that half of current plants in use would have once-through cooling systems, but that all potential new generation would use recirculating (close-loop) systems due to permitting restrictions on open-loop systems. These assumptions are consistent with NETL and EIA data.

Table B.2 Cooling Water Consumption Rates for Common Thermal Power Plant and Cooling System Types with Cooling System Assumptions				
Plant and Cooling System	**Type**	**Estimated Average Water Consumption (gal/MWh)**	**Percent to be Retired by Plant Type**	**Percent to be Built by Plant Type**
Fossil/Biomass/Waste-fueled Steam	Once Through Recirculating	300 400	50 50	0 100
Nuclear Steam	Once Through Recirculating	400 600	50 50	0 100
Natural Gas/Oil Combined-Cycle	Once Through Recirculating	100 180	50 50	0 100

Finally, we assume that the ratio of freshwater to saltwater from power-plant cooling would remain consistent in each of the NERC regions (See Table B.3 for USGS data on the current freshwater and saltwater percentages).

Table B.3 Thermoelectric Power Water Withdrawals for 2000 (in million gallons per day) by Water Type (Fresh/Saline)				
State	**Fresh**	**Saline**	**Total**	**Percent Fresh**
Alabama	8,190	0	8,190	100%
Arkansas	2,180	0	2,180	100%
Delaware	366	738	1,100	33%
D.C.	10	0	10	100%
Florida	658	12,000	12,600	5%
Georgia	3,250	62	3,310	98%
Kentucky	3,260	0	3,260	100%
Louisiana	5,610	0	5,610	100%
Maryland	379	6,260	6,640	6%
Mississippi	362	148	510	71%
North Carolina	7,850	1,620	9,470	83%
Oklahoma	146	0	146	100%
South Carolina	5,710	0	5,710	100%
Tennessee	9,040	0	9,040	100%
Texas	9,820	3,440	13,300	74%
Virginia	3,850	3,580	7,430	52%
West Virginia	3,950	0	3,950	100%
SOUTH TOTAL	64,631	27,850	92,456	70%
US TOTAL	136,000	59,500	195,000	70%

Source: US Geological Survey: Estimated Use of Water in the United States in 2000, http://ga.water.usgs.gov/edu/wupt.html.

APPENDIX C: Spreadsheet Analysis, SNUG-NEMS Modeling, and Results for Residential Policies

Appendix C.1 Residential Spreadsheet Modeling

Appendix C.1.1 Appliance Incentives and Standards

In general, the savings obtained from SNUG-NEMS modeling for Appliance Incentives and Standards appear to be higher than those obtained through spreadsheet modeling (See Table C.1). These calculations include the estimated energy efficiency potential for lighting, which usually is included in appliance category. For this study, lighting was removed from the appliance policy. Therefore, the estimated savings from the spreadsheet calculations will be higher than the SNUG-NEMS modeling.

Table C.1 Delivered Energy Savings for Residential Appliances (Trillion Btu)

Year	Electricity Savings	Natural Gas Savings	Delivered Energy Saved	Percent Savings
2010	178	3	181	17
2020	394	6	399	43
2030	516	7	523	54

Appendix C.1.2 Expanded Weatherization Assistance Program

A Microsoft Excel spreadsheet was used to calculate the altered values inputted into SNUG-NEMS to stimulate an increase in WAP assistance. Several assumptions were made. First, it was assumed that a higher level of funding of one billion dollars per year was allocated to the WAP nationally. Second, it was assumed that each weatherized home cost $2,600. From these two assumptions and the percentage distribution of DOE WAP funds to each census division, the number of households weatherized in each census division was calculated. Third, the life span of weatherization improvements is assumed to be 15 years and assumed to be evenly degraded over its lifetime after two years beyond implementation. The assumed lifetime is lower than the 20 year lifetime assumption used by AEO 2009 for the ARRA expanded WAP program and Schweitzer in the 2005 meta-evaluation of the WAP (personal correspondence, 2009).

Lastly, the savings occurring from weatherization was assumed. The reduction in energy assumed to be 19.8% for electric heat and 32.3% for natural gas heat (Schweitzer, 2005). Martin and Gettings cite two field studies in Oklahoma and Texas, respectively, involving air conditioner replacements. In Oklahoma, a 33% reduction in energy consumption was achieved. In Austin, Texas, a 34% reduction in cooling energy consumption was achieved (1998). Therefore, the reduction in energy for electric cooling from pre-weatherization consumption was assumed to be 33%.

The calculation of the revised SNUG-NEMS input also considers the 2005 heat share of electric and non-electric heat in the census division to reflect regional differences in heating energy sources. The projection of energy consumed by weatherization is dependent on the projected energy consumption per household, which decreases over the study period. Overall, the equations used to calculate the new SNUG-NEMS input numbers are:

Heating Values:

$$\frac{Households\ Weatherized\ in\ CDIV}{Total\ Households\ in\ CDIV} * (19.8\% * Elec.Heat\ \%\ in\ CDIV + 32.3\% * Fossil\ Fuel\ Heat\ \%\ in\ CDIV)$$

Cooling Values:

$$\frac{Households\ Weatherized\ in\ CDIV}{Total\ Households\ in\ CDIV} * 33\%$$

In theory, the number generated from this equation can then be multiplied by the heating or cooling consumption to obtain savings from the WAP. A table of these new values was generated through the spreadsheet calculations divided by heating, cooling, and census division.

APPENDIX C.2 SNUG-NEMS Methodology for Residential Policies

Appendix C.2.1 Building Code Policies

The policies for reducing energy consumption through more stringent building codes are modeled by providing a 30% subsidy in the installation costs for heating, cooling and water heating equipment that are covered by the most stringent building codes in SNUG-NEMS. These are ‘FORTY’ (a home that can heat and cool 40% more efficiently than IECC 2006) and ‘PATH’ (the most efficient home one can build). The building codes that are not incentivized are ‘ENERGY STAR’, ‘No IECC’ and ‘IECC 2006’. See Table C.2 for the efficiencies of the heating, cooling, and water heating equipment within SNUG-NEMS.

Table C.2 Equipment Efficiency for Cooling, Heating, and Water Heating				
Enduse	**Equipment class**	**Efficiency**		
		2010	**2020**	**2030**
Cooling	Central A/C - SEER	13.0-23.0	14.0-23.0	15.0-23.0
	Electric heat pumps - SEER	13.0-19.0	13.0-20.0	13.0-21.0
	Geothermal heat pumps - EER	16.0-30.0	19.0-30.0	19.0-31.0
	Room A/C - EER	10.4-13.0	11.0-13.0	11.0-13.0
Heating	Electric heat pumps - HSPF	7.7-10.8	8.0-11.0	8.0-11.0
	Electric radiators	-	-	-
	Geothermal heat pumps - COP	3.5-5.0	3.9-5.1	3.9-5.1
	LPG furnaces - AFUE	80-96%	81-96%	82-96%
	Natural gas furnaces - AFUE	80-96%	81-96%	82-96%
	Natural gas radiator	-	-	-
Water Heating	Electric water heating - EF	0.95-0.99	0.92-0.95	0.92-0.95
	LPG water heating - EF	0.63-0.86	0.63-1.4	0.86-1.4
	Natural gas water heating - EF	0.80-0.85	0.80-0.85	0.80-0.86
	Solar water heating - EF	0.8-4.8	0.8-4.8	0.8-4.8

The subsidies for the shell installation cost of the equipment corresponding to the most stringent codes were applied to the rtektyc.v1.103 file. Starting in 2009, the least rigorous code is eliminated every 6 years and only the more stringent ones are allowed to remain. The table below shows the year in which a code was eliminated.

Table C.3 Years of Building Code Implementation	
Building Code	**End Date**
'No IECC'	2009
'IECC 2006'	2009
'ENERGY STAR'	2015
'FORTY'	2021
'PATH'	2030

The number of homes that were affected by the policy at the end of the period was calculated by first finding the difference in the number of new equipment purchased between the reference case and the policy case. We found that the effect of the subsidy on installation costs was to increase the number of equipment required by the stringent codes that were purchased. However, the cost per unit remained the same because we did not incentivize the cost of the equipment itself in this policy. Those equipment types that were not incentivized reduced in number while those that were subsidized increased in number. Since each subsidized code applies to the number of homes built to that code in SNUG-NEMS, adding up the number of new equipment types (both positive and negative) provided us with an estimate of households affected by our policy in a given year. The main assumption here is that each home has one main unit for heating, cooling and water heating respectively. Since the subsidy was applied uniformly to this bundle of equipment for all the homes covered under a given code, the net difference in new equipment provides us with an estimate of the number of homes that were impacted by our policy.

Appendix C.2.2 Residential Retrofit Incentives & Equipment Standards

Residential subsidy for efficient retrofit appliances is implemented by making changes to the rtekty.v1.179 residential input file in SNUG-NEMS detailing equipment and appliance efficiencies and costs. Only equipment classes that had an efficiency improvement during the study period received the subsidy for the highest efficiency equipment within the class. For these, a 30% reduction in their cost was given. See Table C.4 for the equipment that received incentives.

Table C.4 Equipment Receiving 30% Incentives*

Equipment	Details
Electric Heat Pump	ELEC_HP4
Natural Gas Furnace	NG_FA#5
Natural Gas Radiator	NG_RAD3
Kerosene Furnace	KERO_FA3
LPG Furnace	LPG_FA#5
Distillate Furnace	DIST_FA3
Distillate Radiator	DISTRAD3
Geothermal Heat Pump	GEO_HP2
Room Air Conditioner	RM_AIR# 2 & 3*
Central Air Conditioner	CT_AIR#4
Natural Gas Water Heater	NG_WH#4
Electric Water Heater	ELEC_WH5
Distillate Water Heater	DIST_WH3
LPG Water Heater	LPG_WH#4

*Due to the large price differential, RM_AIR#3 still had little selection after subsidization. Therefore, RM_AIR#2 was also subsidized to encourage high efficiency room air conditioners.

The equipment standard is implemented in the same file. In general, when the standard is up for renewal, the most inefficient technologies were removed. Since many of the inefficient equipment efficiencies differed very little, this sometimes led to all equipment within an efficiency grouping to be eliminated.

Ten years after the date, the next lowest equipment was removed to simulate a renewal of the standard. The renewal dates for the standards are taken from Neubauer et al. in a study done for the American Council for an Energy-Efficient Economy and the Appliance Standards Awareness Project and Appliance Standards Awareness Project. In some cases, where there were only two main groupings of equipment efficiency, the standard was not renewed. For all equipment except room air conditioners, the number of input lines was increased to created dates corresponding to the policy durations. See Table C.5 for the equipment affected by the Residential Equipment Standards.

Table C.5 Equipment Standards Implementation and Renewal Dates*		
Equipment	**Year Standard Implemented**	**Year Standard Renewed**
Electric Heat Pump	ELEC_HP1 & 2 (2014)	ELEC_HP3 (2024)
Natural Gas Furnace	NG_FA#1, 2, & 3 (2014)	NG_FA#4 (2024)
Natural Gas Radiator	NG_RAD1 & 2 (2013)	---
Kerosene Furnace	KERO_FA1 & 2 (2015)	---
LPG Furnace	LPG_FA#1, 2, & 3 (2015)	LPG_FA#4 (2025)
Distillate Furnace	DIST_FA1 & 2 (2015)	---
Distillate Radiator	DISTRAD1 & 2 (2013)	---
Geothermal Heat Pump	GEO_HP1 (2014)	---
Natural Gas Heat Pump	NG_HP (2014)	---
Room Air Conditioning	RM_AIR#1 (2006)*	---
Central Air Conditioning	CT+AIR#1 & 2 (2014)	CT_AIR#3 (2024)
Natural Gas Water Heater	NG_WH#1 & 2 (2013)	NG_WH#3 (2023)
Electric Water Heater	ELEC_WH1, 2, & 3 (2013)	ELEC_WH4 (2024)
Distillate Water Heater	DIST_WH1 & 2 (2013)	---
LPG Water Heater	LPG_WH#1 & 2 (2013)	LPG_WH#3 (2023)

*See paragraph below for explanation

Standards were implemented by increasing the price of the equipment arbitrarily high to $999,999. Room air conditioners cannot have input lines increased in the rtekty.v1.179 file (Personal communication with John Cymbalsky, December 30, 2009). For these, the price was arbitrarily increased for the dates that were available. Because of this, the standard for room air conditioners was implemented early in 2006.

Table C.6 lists equipment, their efficiencies, and their percentage of use in the reference and policy scenarios to show how technology demand has shifted. The numbers listed in the efficiency column are derived from the SNUG-NEMS input file. Some numbers exceed one since they include traditional efficiency numbers and efficiency as rated by usage. This also explains why some values increase with greater efficiency and why others decrease. Equipment with only one efficiency displayed is usually the most efficient equipment offered.

Table C.6 Total Technology Demand Shifts from Residential Retrofit Incentives and Equipment Standards Policy*						
Description	**Efficiency**		**Reference**		**Policy**	
	2020	**2030**	**2020**	**2030**	**2020**	**2030**
Central Air	4.69	---	29%	33%	35%	0%
	6.74	---	6%	7%	65%	100%
Room Air Conditioner	3.17	---	31%	32%	100%	100%
	3.52	---	0%	0%	0%	0%
Distillate Furnace	0.95	---	13%	12%	100%	100%
Kerosene Furnace	0.95	---	15%	22%	100%	100%
LPG Furnace	0.90	---	28%	28%	41%	0%
	0.96	---	18%	17%	59%	100%
Natural Gas Furnace	0.90	0.90	40%	35%	41%	0%
	0.96	0.96	12%	12%	59%	100%
Distillate Radiator	0.95	---	44%	41%	100%	100%
Natural Gas Radiator	0.95	---	14%	12%	100%	0%
Electric Heat Pump	2.78/4.84	2.8/4.98	9%	10%	22%	0%
	3.17/5.57	3.19/5.86	11%	10%	78%	100%
Geothermal Heat Pump	5/30	---	9%	15%	100%	100%
Natural Gas Heat Pump	1.4/0.67	---	100%	100%	100%	0%
Distillate Water Heater	0.68	---	30%	33%	100%	100%
Electric Water Heater	2.30	---	4%	10%	40%	0%
	2.40	---	0%	0%	60%	100%
LPG Water Heater	0.64	---	5%	2%	0%	0%
	0.84	0.85	87%	95%	100%	100%
Natural Gas Water Heater	0.64	---	23%	24%	25%	0%
	0.84	0.85	1%	5%	75%	100%

*Heat pumps have two efficiencies displayed. The first number is for heating while the second is for cooling. Equipment with the same efficiencies for 2020 and 2030 have the efficiencies listed in 2020 and a dash for 2030.

Appendix C.2.3 Appliance Incentives & Standards

Residential Appliance Incentives for efficient retrofit appliances was implemented by making changes to the rtekty.v1.179 residential input file in SNUG-NEMS detailing equipment and appliance efficiencies and costs. Only end-uses that had an efficiency improvement during the study period received the subsidy for the highest efficiency equipment within the class. For these, a 30% reduction in their cost was given (See Table C.7).

Table C.7 Appliances Receiving 30% Incentives

Appliance	Details
Clothes Washer	CW#3
Dish Washer	DW#3
Natural Gas Stove	NG_STV2
LPG Stove	LPG_STV2
Refrigerator	Ref#4
Freezer	Freez#3

The appliance standard is implemented in the same file. When the standard is up for renewal, the most inefficient technologies are removed. Ten years after the date, the next lowest appliance is removed to simulate a renewal of the appliance standard. The renewal dates for the standards are taken from Neubauer et al. in a study done for the American Council for an Energy-Efficient Economy and the Appliance Standards Awareness Project and the Appliance Standard Awareness Project. See Table C.8 for the appliances affected by the standards.

Table C.8 Appliance Standards Implementation and Renewal Dates

Appliance	Year Standard Implemented	Year Standard Renewed
Clothes Washer	CW#1 & 2 (2015)	---
Dish Washer	DW#1 (2018)	DW#2 (2028)
Natural Gas Stove	NG_STV1 (2020)	---
LPG Stove	LPG_STV1 (2020)	---
Refrigerator	Ref#1 & 2 (2013)	Ref#3 (2024)
Freezer	Freez#1 (2013)	Freez#2 (2023)

Natural gas water heater projections did not seem to respond to alterations within the input file. Because of this, they were left out of the standards and incentives implemented in the rtekty.v1.179 input file.

Table C.9 lists the appliances, their efficiencies, and their percentage of use in the reference and policy scenarios. The numbers listed in the efficiency column are derived from the SNUG-NEMS input file. Some numbers are traditional efficiency numbers, while others are efficiency as rated by usage. This explains why some efficiency numbers increase with greater efficiency while others decrease.

Table C.9 Total Technology Demand Shifts from Appliance Incentives and Standards Policy					
Description	**Efficiency**	**Reference**		**Policy**	
		2020	**2030**	**2020**	**2030**
Clothes Washer	0.114	29%	33%	100%	100%
Dish Washer	0.65	52%	52%	0%	0%
	0.35	0%	0%	100%	100%
Freezer	350	15%	16%	4%	0%
	302	7%	7%	53%	57%
LPG Stove	0.399	75%	74%	30%	0%
	0.420	25%	26%	70%	100%
Natural Gas Stove	0.399	82%	82%	29%	0%
	0.420	2%	18%	71%	100%
Refrigerator	434	1%	2%	26%	0%
	417	0%	0%	24%	71%

Appendix C.2.4   Expanded Weatherization Assistance Program

The Expanded Weatherization Assistance Program modeling was conducted through alterations to the rmisc.v1.180 input file. The table of new values generated through the spreadsheet calculations replaced the existing table in the SNUG-NEMS input code within the rmisc.v1.180 file (See Figure C.1). Afterwards, SNUG-NEMS was run to project the savings from the expanded WAP.

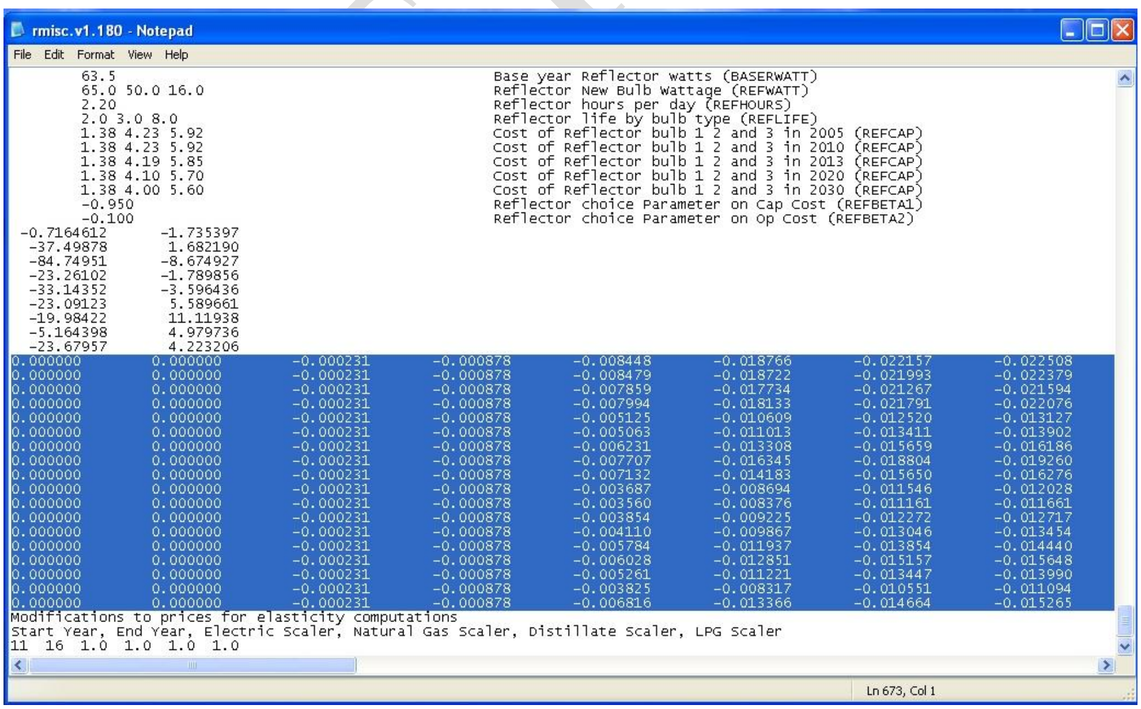

Figure C.1 Table of WAP Associated Values in the SNUG-NEMS Input File

Appendix C.3 Energy Efficiency Potential, Economic Value, and Cost Calculations

Energy consumption and prices by fuel were obtained from the SNUG-NEMS output using Graf2000. The difference between the baseline consumption and the policy consumption was taken to obtain the energy efficiency potential from the policy by fuel type. Electricity related losses were calculated by using the 2.159 conversion obtained from 2007 historical electricity losses for the South. The economic value of the energy savings was determined by taking the difference between the non-renewable energy expenditures of the baseline case and the policy case.

Private cost was obtained from the RESDEQP output file, which provided information on new and replacement investment cost. These values were summed up for the three census divisions being studied. In the case of the retrofit and appliance policies, public investment cost was obtained by first calculating the subsidy amount for each piece of equipment by taking the difference between the rtekty input files for the stimulus and the policy case. This subsidy was then multiplied by the total number of each equipment or appliance implemented during its applicable durations. The amount of new or replacement installations of the technologies were also obtained from the RESDEQP output file. The net present value was obtained using a discount rate of 7% for all residential policies.

In the case of building codes, administrative costs are based on one administrator per state at a salary of $150,000 per annum and an employee at $75,000 per annum. It also includes an additional employee for the verification of every 100,000 homes in the state at $75,000 per year (ARC report, 2009). The savings are extrapolated to 2050 in order to account for the extra savings that accrue through the lifetime of the appliances adopted in 2030.

For the appliance standards and incentives policy, administrative costs are assumed to be $0.13 per MBtu (Brown et al., 2009b). The investment costs were from the SNUG-NEMS output files. The energy bill savings are extrapolated to 2045 to account for the appliances adopted in 2030 using an estimated lifetime.

APPENDIX D: Spreadsheet Analysis, SNUG-NEMS Modeling, and Results for Commercial Policies

Appendix D.1 Commercial Appliance Standards Policy

In SNUG-NEMS, the commercial appliance standards policy is implemented through making changes to two NEMS input files: ktek and kdeleff.

The ktek file is the commercial sector technology input file where technologies are grouped by end use. The seven technologies include space heating, space cooling, water heating, ventilation, cooking, lighting, and refrigeration. The following snapshot presents the organization of data in the ktek file:

```
ORGANIZATION OF DATA:

Columns are divided into labeled fields which have the following meanings:

t-technology index, arbitrarily assigned to a technology class for use by
NEMS.  Must have a value between 1 and the Commercial Module parameter
CMNumTech.

v-technology vintage index, arbitrarily assigned to a "model" within a
technology class.   Must have a value between 1 and the Commercial Module
parameter CMNumEqvint.

t and v together uniquely identify an equipment type.

r-Census Division index. 1 - New England, 2 - Middle Atlantic, 3 - East North
Central, 4 - West North Central, 5 - South Atlantic, 6 - East South Central,
7-West South Central, 8-Mountain, 9-Pacific; BUILDING TYPE for vent,light,refrig

s-index of service demand.  1- Space Heating, 2 - Space Cooling, 3 - Water
Heating, 4 - Ventilation, 5 - Cooking, 6 - Lighting, 7 - Refrigeration

f-index of fuel used by the technology class.  1 - Electricity, 2 - Natural
Gas, 3 - Distillate

Shr - Initial market share of Service Demand.  The current base year for CSDM
is 2003, so only equipment that was available in 2003 should have a nonzero
market share in KTECH.  Market shares are defined such that they sum to 1
across all equipment providing a specific service within a specific Census
Division.  Note that Market Share of Service Demand differs from Market Share
of Consumption, but is related by equipment efficiency.

Eff - Equipment efficiency or Coefficient of Performance (as appropriate).
For most services eff is in units of Btu output per Btu input.
For ventilation systems eff is in units of 1000 cfm-hours output per 1000 Btu input.
For lighting equipment eff is Efficacy in units of Lumens per Watt.

c1 - Unit installed Capital Cost per unit of Service Demand
(2007$/1000 Btu out/hour)

c2 - Operating and Maintenance Cost (2007$/1000 Btu out/hour)

for ventilation, c1 and c2 units are 2007$/1000 cfm

for lighting, c1 and c2 units are 2007$/1000 Lumen

Life - Expected Equipment Lifetime, years

y1 - First calendar year of availability for purchase

y2 - Last calendar year of availability for purchase

r1 through r11 are building restrictions to block equipment from certain building types
(the restrictions have no meaning for lighting)

retro is the retrofitting cost of discarding the old technology

techtype, trendstart, trend1 and trend2 are paramaters for cost declines for
immature technologies
```

Figure D.1 ktek File Data Organization

Within each of the seven end uses there are numerous technologies which each have multiple vintages representing the levels of energy efficiency. Many of these commercial appliance technologies already have federal standards in place, but some are open to states setting their own standards. The reason for this is that either no federal standard exists or a federal standard does exist but certain states have received exemptions from the federal preemption (i.e. California). The following table illustrates the commercial appliance technologies which have existing federal standards and technologies which are open to states setting their own standard.

Table D.1 Commercial Appliance Standards

Existing Federal Standard	State Standard Possible
Commercial Ground Source Heat Pump (GSHP) - Cooling	CAV Vent
Commercial Ground Source Heat Pump (GSHP) - Heating	Centrifugal chillers
Electric Booster Water Heaters	Electric Boilers
Gas-Fired Boilers	Gas Rooftop Air Conditioning
Gas Booster Water Heaters	HP Water Heater [1]
Gas Chillers	Reciprocating Chillers
Gas Chiller Absorption	Residential Gas HP - Cooling
Gas-Fired Furnaces	Residential Gas HP - Heating
Gas-Fired Instantaneous Water Heaters	Screw Chillers
Gas Water Heater	Scroll Chillers
Ice Machines	Solar Water Heaters
Oil-Fired Boilers	VAV Vent
Oil-Fired Furnaces	Vending Machines [2]
Oil-Fired Water Heaters	Walk-in Freezers[2]
Residential Central AC	Walk-in Refrigerators [2]
Rooftop AC	Wall Window Room AC[1]
Rooftop Air Source Heat Pump (ASHP) - Cooling	
Rooftop Air Source Heat Pump (ASHP) - Heating	
Supermarket Compressor Racks	
Supermarket Condensers	
Supermarket Display Case	

[1]No standard found

[2]Federal standard is in place, but certain states have received specific exemptions to federal preemption

In SNUG-NEMS, we set more stringent standards to disable the purchase of low and mid-low efficiency appliances and encourage demand to shift to high efficiency technologies. The four types of changes to the ktek file are illustrated below, and the first block is the default ktek file whereas the second block shows the modifications made to represent our policy:

1. Change the end year of low efficiency appliances (represented by“2003 installed base”/ “installed base”) from 2040 to 2009, lighting is not included.

99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
227	46	1	1	1	1	0.0168	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
228	46	1	2	1	1	0.0352	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
229	46	1	3	1	1	0.0571	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
230	46	1	4	1	1	0.0809	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
231	46	1	5	1	1	0.0903	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
232	46	1	6	1	1	0.0356	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
233	46	1	7	1	1	0.1193	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
234	46	1	8	1	1	0.0695	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base
235	46	1	9	1	1	0.1085	0.94	17.53	0.58	21	2003	2040	1	elec_boiler 2003 installed base

99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
227	46	1	1	1	1	0.0168	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
228	46	1	2	1	1	0.0352	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
229	46	1	3	1	1	0.0571	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
230	46	1	4	1	1	0.0809	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
231	46	1	5	1	1	0.0903	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
232	46	1	6	1	1	0.0356	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
233	46	1	7	1	1	0.1193	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
234	46	1	8	1	1	0.0695	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base
235	46	1	9	1	1	0.1085	0.94	17.53	0.58	21	2003	2009	1	elec_boiler 2003 installed base

Figure D.2 ktek File Changes-Low Efficiency Appliance

2. Change the end year of mid-low efficiency appliances (represented by “2007 typical”/” 2008 low and typical”) to 2009 (the original end years vary), lighting is not included.

99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
272	3	2	1	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
273	3	2	2	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
274	3	2	3	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
275	3	2	4	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
276	3	2	5	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
277	3	2	6	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
278	3	2	7	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
279	3	2	8	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical
280	3	2	9	1	2	0	1.40	158.33	2.50	15	2003	2040	1	res_type_gasHP-heat 2007 typical

99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
272	3	2	1	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
273	3	2	2	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
274	3	2	3	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
275	3	2	4	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
276	3	2	5	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
277	3	2	6	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
278	3	2	7	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
279	3	2	8	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical
280	3	2	9	1	2	0	1.40	158.33	2.50	15	2003	2009	1	res_type_gasHP-heat 2007 typical

Figure D.3 ktek File Changes-Mid-low Efficiency Appliances

3. Push back the beginning year of “2010 typical” from 2010 to 2031, lighting is not included.

99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
128	1	4	1	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
129	1	4	2	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
130	1	4	3	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
131	1	4	4	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
132	1	4	5	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
133	1	4	6	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
134	1	4	7	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
135	1	4	8	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical
136	1	4	9	1	1	0	3.30	76.67	1.39	15	2010	2040	1	rooftop_ASHP-heat 2010 typical

99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
128	1	4	1	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
129	1	4	2	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
130	1	4	3	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
131	1	4	4	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
132	1	4	5	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
133	1	4	6	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
134	1	4	7	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
135	1	4	8	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical
136	1	4	9	1	1	0	3.30	76.67	1.39	15	2031	2040	1	rooftop_ASHP-heat 2010 typical

Figure D.4 ktek File Changes-Beginning Years

The first two changes disable the purchase of low and mid-low efficiency appliances by the end of 2009. The third change defers the purchase of mid-low efficiency appliances until 2031. After making the changes, the majority of the available appliance options between the years 2010 and 2030 will be high efficiency appliances (seen as 2010 high/ 2020high/ 2020typical). Therefore, we shift the demand of commercial appliances from low efficiency to high efficiency ones and the energy consumption in the commercial sector is reduced as a result.

4. Changes made to lighting: the end year for lighting technologies with low energy efficiency (efficiency factor smaller than 65), was changed to 2014. The following table lists these specific vintages that our program incentivizes, with the model technology (T) and vintage (V) identifiers shown:

Table D.2 Lighting Technologies

T	V	Technology
25	3	F32T8
24	3 and 9	90W Halogen PAR-38
25	4	F32T8 HE
25	2	T8 F32 EEMag (e)
27	2	MH 175
24	1	100W Inc
25	1	F34T12
26	1	F96T12 Magnetic
25	6	F32T8 HE with OS
27	3	HPS70
27	1	MV175
25	9	120W Halogen PAR-38 (e)

Table D.2 Lighting Technologies		
T	**V**	**Technology**
24	4 and 10	70W HIR PAR-38
24	7	72W Inc (Halogena Type HIR)

The kdeleff file contains information about annual efficiency improvement for minor services, which includes Office Equipment (PCs), Office Equipment (Non-PCs), and Other Uses. These three sectors have no default annual efficiency improvement. In our standard policy, we apply 2% annual efficiency improvement so that the energy efficiency keeps increasing for those three types of end uses. The following snapshots show the organization of the kdeleff data in SNUG-NEMS and the changes that were made to accommodate the efficiency improvements:

```
FILE NAME:    KDELEFF            August 31, 2005 - Version for AEO06, improvement now incorporated in koffpen trend

CONTACT:      Erin Boedecker(DOE/EIA) (202) 586-4791
              NEMS Commercial Sector Analyst

USED BY:      Technology Choice subroutine of the National Energy Modeling
              System (NEMS) Commercial Sector Demand Module

DEFINITION:   Annual efficiency improvement for minor services

              Proportional annual efficiency improvement applied to the previous
              year's average efficiency starting in 1990 for the minor services:
              Office Equipment - PC, Office Equipment - NonPC, Other

UNITS:        unitless

SPECIAL CONSTRAINTS:  None

DIMENSION:    by service

ORGANIZATION OF DATA:

     Each column corresponds to a service, in the following order:  Space
     Heating, Space Cooling, Water Heating, Ventilation, Cooking, Lighting,
     Refrigeration, Office Equipment - PCs, Office Equipment - NonPCs, other.
     Columns corresponding to major services are used only as place holders.
```

Figure D.5 kdeleff File Data Organization

The default kdeleff annual efficiency setting is shown first (Figure D.6) and then the incorporation of the 2% annual efficiency improvements in the three sectors (Figure D.7):

[illegible]

Figure D.6 kdeleff-Default

```
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.02   0.02   0.02
```

Figure D.7 kdeleff Changes

The commercial source code was also modified because there is no time parameter in kdeleff. The above changes lead to efficiency gains years before 2010 without this accompanying source code change (Figure D.8). In the actual SNUG-NEMS source code, these changes do not make up a continuous block of code.

```
! For pre 2010 Other end use, do not change the efficiency growth
IF (CURIYR.LT.21) THEN
      CEffGrowth(s)=0.0 ! old values up to 2009
ELSE
      CEffGrowth(s)=EffGrowthRate(s)  ! Effic index
ENDIF     ! End of fix

! Change to be consistent with above (do not modify pre-2010)
IF (CURIYR.LT.21) THEN
     AverageEfficiency (r,b,s,1)=  & ! electric only
        PrevYrAverageEfficiency (r,b,s,1) * &
        (1.0 + 0.0)
ELSE
      AverageEfficiency (r,b,s,1)=  & ! electric only
        PrevYrAverageEfficiency (r,b,s,1) * &
        (1.0 + EffGrowthRate (s))
ENDIF   ! END of fix
```

Figure D.8 SNUG-NEMS Source Code Changes

Appendix D.2 HVAC Retrofit Policy

Modeling the retrofit policy was implemented in SNUG-NEMS by modifying the default commercial building technology input file: ktek.v1.8.xml.

The Figure D.9, below, illustrates one example of the many similar changes made to the ktek input file. The highlighted portion of the image emphasizes the incentive made to this particular technology and vintage. The capital cost of installation was reduced from 11.57 to 8.11 (2007$/1000 Btu out/hour.)

98								Cap_cost	O&M_cost				retrofit	
99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
373	48	7	3	1	2	0	0.88	11.57	0.86	20	2020	2040	1	gas_furnace 2020 high

98								Cap_cost	O&M_cost				retrofit	
99	t	v	r	s	f	Shr	eff	c1	c2	Life	y1	y2	cost	technology name
373	48	7	3	1	2	0	0.88	8.11	0.86	20	2020	2040	1	gas_furnace 2020 high

Figure D.9 ktek File Change-Capital Cost

Table D.3 provides a list of the specific vintages that our program incentivizes, with the model technology (T) and vintage (V) identifiers shown. Note that the two ventilation technologies were incentivized by 9% rather than 30%.

Table D.3 Incentivized Technologies

T	V	Technology	Incentive Level
48	7	gas_furnace 2020 high	30%
49	6	gas_boiler 2010 high	30%
13	5	reciprocating_chiller 2010 high	30%
14	7	centrifugal_chiller 2010 high	30%
52	6	rooftop_AC 2010 high	30%
53	5	wall-window_room_AC 2007 high	30%
54	8	res_type_central_AC 2010 high	30%
31	6	CAV_Vent 2010 high	9%
32	6	VAV_Vent 2010 high	9%

This list of technologies represents three of the seven major end uses for which demand is modeled in the commercial module. These three end uses are space heating, space cooling, and ventilation. Within space heating, a single vintage in three of nine technologies are incentivized. From space cooling, one vintage from six of thirteen technologies are incentivized. Each of the two ventilation technologies modeled had a vintage incentivized.

Appendix D.3 Economic Test Assumptions

In total resource test, a greater than one benefit-cost ratio indicates the economic effectiveness of the policy. In this study, the energy efficiency benefits are the energy bill savings resulted from each policy. On the side, the costs include both private investment cost and public investment cost. Private investment costs are consumer’s spent on energy efficiency measures. Public investment costs include the program administrative cost which is the expenditure to hire program administrators and run the program. For HVAC retrofit policy, the subsidies on particular end use technologies is also included as public investment.

SNUG-NEMS reports the private investment and subsidies can be estimated based on SNUG-NEMS output. However, the administrative costs are neither reported nor estimated by SNUG-NEMS. Therefore, we need to calculate it externally.

Appendix D.3.1 Assumptions for Administrative Costs

Standards policy: For each state, an administration office and four administrators are needed. It is assumed that the annual operation cost to run the office is $150,000 and the annual salary for each administrator is $75,000.

HVAC Retrofit policy: Similarly, there is an administration office running at $150,000 per year to oversee the HVAC retrofit program. Retrofitters who are paid at $75,000 per year are sent out to help business to identify their retrofitting opportunities. The number of retrofitter for each state is based on the state population. It is assumed that each 200,000 population requires one retrofitter.

Commercial combined policy: The administrative cost for the commercial combined policy is the summation of the administrative cost of standards policy and HVAC retrofit policy.

Appendix D.3.2 Assumptions for Investment Costs in Standards Policy

In SNUG-NEMS, commercial sector energy savings come from 10 types of end uses

- Space heating
- Space cooling
- Water heating
- Ventilation
- Cooking
- Lighting
- Refrigeration
- Office Equipment (PC)
- Office Equipment (Non PC)
- Other[1]

However, SNUG-NEMS only reports the investment cost associated with the first seven end uses in the output file named "KRPT". The investment cost related to "Office Equipment (PC)", "Office Equipment (Non PC)" and "Other" needs to be estimated externally.

Though there are a lot studies focus on understanding the energy efficiency potential in commercial sector and its related cost, few of them give a direct estimate of the investment costs for office equipments and the other sources of commercial energy uses that are not covered in the first nine types of end uses listed above. Meanwhile, according to our study the saving from these end uses composes a large portion of the total energy saving (over 1/3 of the energy saving in 2030 comes from office equipments and other end uses). Therefore, it is important to understand how much it costs to achieve the energy efficiency improvement in those end uses.

In this study we developed our own method to estimate the investment costs. We based our estimation on the levelized cost of energy efficiency from two sources. One is from McKinsey and Company (2009) where the cost for energy efficiency from office equipments and other end uses is estimated to be $2.7/MMBtu. At the same time, this study estimated the cost for standards and retrofit policy is $9.2/MMBtu and $12.3/MMBtu. This presents an opportunity to explore a range of cost related to office equipments and others. However, for the simplicity of this study only the Total Resource Test result based on the mid-range number ($9.2/MMBtu) is shown in the report.

[1] The "Other" includes miscellaneous uses, such as service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, liquefied petroleum gases, coal, motor gasoline and kerosene.

Appendix D.4 Results of Commercial Policy Bundle Annual Cost and Benefit

Table D.4 shows the annual cost and benefit resulted from commercial energy efficiency policy bundle.

Table D.4 Annual Cost and Benefits from Commercial Policies (Billion 07$)

Year	Standard Policy		Retrofit Policy		Commercial Combined Policies	
	Cost	Benefit	Cost	Benefit	Cost	Benefit
2010	1.8	1.2	0.6	0.1	2.7	1.2
2011	1.9	2.0	0.6	0.4	2.7	2.0
2012	2.0	2.5	0.5	0.5	2.8	2.6
2013	2.1	3.0	0.6	0.6	3.0	3.1
2014	2.3	3.8	0.6	0.8	3.2	3.8
2015	2.4	4.8	0.6	0.9	3.4	4.8
2016	2.6	5.9	0.7	1.1	3.6	5.9
2017	2.7	7.0	0.7	1.2	3.7	7.1
2018	2.8	8.3	0.7	1.4	3.8	8.5
2019	2.9	9.4	0.7	1.4	4.0	9.7
2020	1.8	10.4	1.1	1.7	4.4	10.9
2021	2.0	10.9	1.1	1.8	4.5	11.6
2022	2.1	11.5	1.1	1.8	4.7	112.4
2023	2.2	12.8	1.1	2.4	4.9	13.9
2024	2.4	14.1	1.1	2.6	5.0	15.5
2025	2.5	14.4	1.1	2.8	5.2	16.0
2026	2.7	14.9	1.1	2.7	5.4	16.6
2027	2.8	16.1	1.1	3.2	5.6	18.1
2028	3.0	17.2	1.2	3.3	5.8	19.5
2029	3.2	17.7	1.2	3.5	6.0	20.2
2030	3.3	19.1	1.2	3.3	6.2	21.1

Appendix D.5 Results of Technology Demand Change

Table D.5 to Table D.10 present the energy demand changes between 2020 and 2030 in 6 types of commercial end uses. Comparing between reference baseline and policy results, it is shown that energy demand is shifted from less efficient technology equipments to high efficiency equipments.

Table D.5 Space Heating Technologies Demand Changes

Description	Efficiency	Reference		Policy	
		2020	2030	2020	2030
Rooftop Air Source Heat Pump-Heating	3.30	100%	100%	32%	30%
	3.40	0%	0%	68%	70%
Commercial Ground Source Heat Pump-Heating	3.50	93%	100%	0%	0%
	4.00	7%	0%	100%	100%
Residential Type Gas Heat Pump-Heating	1.00	0%	0%	0%	0%
	1.40	100%	100%	0%	100%
Electric Boiler	0.94	100%	100%	0%	0%
Gas Furnace	0.79	59%	0%	0%	0%
	0.80	0%	60%	0%	0%
	0.88	41%	0%	100%	100%
	0.89	0%	40%	0%	0%
Gas Boiler	0.77	94%	94%	0%	0%
	0.80	3%	2%	0%	0%
	0.91	3%	4%	100%	100%
Oil Furnace	0.79	100%	100%	0%	100%
Oil Boiler	0.78	26%	22%	0%	0%
	0.84	74%	78%	100%	100%

Table D.6 Space Cooling Technologies Demand Changes					
Description	**Efficiency**	**Reference**		**Policy**	
		2020	**2030**	**2020**	**2030**
Rooftop Air South Heat Pump-Cooling	3.22	100%	100%	31%	29%
	3.52	0%	0%	69%	71%
Commercial Ground Source Heat Pump-Cooling	4.10	100%	100%	100%	100%
	8.15	0%	0%	0%	0%
Residential Type Gas Heat Pump-Cooling	0.67	100%	100%	0%	100%
Scroll Chiller	3.08	100%	100%	0%	100%
Screw Chiller	2.93	0%	8%	0%	0%
	3.91	0%	92%	0%	0%
Reciprocating Chiller	2.43	65%	53%	0%	0%
	3.63	35%	0%	100%	100%
	3.78	0%	47%	0%	0%
Centrifugal Chiller	4.69	70%	67%	0%	0%
	7.00	30%	33%	0%	0%
	7.30	0%	0%	100%	100%
Gas Chiller	1.21	67%	65%	66%	64%
	1.67	33%	35%	34%	36%
Rooftop AC	3.28	100%	100%	0%	0%
	3.52	0%	0%	100%	100%
Wall-window Room AC	2.87	100%	100%	0%	0%
	3.05	0%	0%	100%	0%
	3.11	0%	0%	0%	100%
Residential Type Center AC	3.81	100%	100%	0%	0%
	4.10	0%	0%	100%	99%
	6.74	0%	0%	0%	1%

Table D.7 Water Heating Technologies Demand Changes					
Description	**Efficiency**	**Reference**		**Policy**	
		2020	**2030**	**2020**	**2030**
HP Water Heater	2.30	100%	100%	0%	0%
	2.40	0%	0%	100%	100%
Gas Water Heater	0.78	55%	53%	0%	0%
	0.93	45%	47%	100%	100%
Oil Water Heater	0.78	60%	55%	0%	0%
	0.80	40%	45%	100%	100%

Table D.8 Refrigerator Technologies Demand Changes					
Description	Efficiency	Reference		Policy	
		2020	2030	2020	2030
Supermarket Compressor Rack	2.45	52%	52%	0%	0%
	2.70	0%	0%	52%	52%
	3.06	48%	48%	48%	48%
Supermarket Condenser	17.82	52%	52%	0%	0%
	27.84	48%	48%	100%	100%
Supermarket Display Case	2.28	73%	73%	0%	0%
	2.45	27%	27%	100%	100%
Walk-In Refrigerator 2008 high	6.24	0%	0%	100%	100%
	6.73	100%	100%	0%	0%
Reach-In Refrigerator	3.21	52%	52%	52%	52%
	5.13	48%	48%	48%	48%
Reach-In Freezer	1.41	52%	52%	55%	52%
	2.26	48%	48%	45%	48%
Ice Machine	0.52	27%	27%	27%	27%
	0.57	73%	73%	73%	73%
Vender Machine	0.53	53%	52%	0%	0%
	0.75	37%	27%	89%	89%
	1.06	11%	21%	11%	11%

Table D.9 Ventilation Technologies Demand Changes					
Description	Efficiency	Reference		Policy	
		2020	2030	2020	2030
CAV_Vent	0.29	45%	31%	0%	0%
	0.59	44%	0%	0%	0%
	1.10	11%	69%	100%	100%
VAV_Vent	0.31	44%	45%	0%	0%
	0.63	36%	32%	0%	0%
	1.63	20%	24%	100%	100%

Table D.10 Cooking Technologies Demand Changes					
Description	Efficiency	Reference		Policy	
		2020	2030	2020	2030
Electric Range	0.70	46%	46%	47%	47%
	0.80	54%	54%	53%	53%
Gas Range	0.45	44%	44%	46%	44%
	0.60	56%	56%	54%	56%

Appendix E: Spreadsheet Analysis, SNUG-NEMS Modeling, and Results for Industrial Policies

Appendix E.1 Analysis of Energy Savings Potential for Small and Medium-Sized Enterprises (SMEs)

The U.S. Department of Energy's Industrial Assessment Center (IAC) database is used to determine the baseline of energy consumption for small and medium-sized industrial sites (less than $2.5 million in energy consumption per year) by source of energy (electricity, natural gas, LPG, fuel oil, coal and wood) for each state. The IAC assessments include information such as the North American Industry Classification System (NAICS) code, energy efficiency recommendations, and potential energy savings.

Data on the value of shipments, organized by establishment, are used to assess the size of industrial firms for this analysis. These data are collected from the Manufacturing Energy Consumption Survey (MECS) and are compiled by the NAICS code (three digits) into three census divisions (West South Central, East South Central, and South Atlantic) in order to get an average baseline energy savings. Finally, with updated information on energy costs by state, it is possible to obtain the weighted-energy savings – by type of establishment – for small and medium-sized industrial firms.

The DOE industrial assessments have an implementation rate of approximately 50%, but in order to quantify the full potential of this policy, this study will assume that 80% of the recommendations will be implemented. This could be possible only if each state implements policies in support of the fulfillment of these recommendations by firms, through education, outreach, and financial assistance.

Table E.1 IAC Assessments to Date

Region	State	# of Assessments	Actions	Average Potential Payback of Recommended Actions (years)	Implemented Actions	Average Payback of Implemented Actions (years)	Rate (%)
ESC	AL	131	969	1.5	378	1.3	0.39
	KY	205	1298	1.2	468	1.0	0.36
	MS	311	2036	1.1	733	0.9	0.36
	TN	480	3072	1.0	1367	0.8	0.45
WSC	AK	293	2074	0.9	1208	0.8	0.58
	LA	260	1819	0.7	972	0.7	0.53
	OK	655	4281	1.4	2088	1.2	0.49
	TX	838	6276	0.8	3539	0.6	0.56
SA	DE	40	320	1.4	81	0.7	0.25
	DC	151	937	1.7	438	1.6	0.47
	Fl	564	4416	1.4	1801	1.1	0.41
	GA	661	4505	1.6	1950	1.5	0.43
	MD	54	439	1.0	181	0.9	0.41
	NC	505	3603	1.1	1760	0.9	0.49
	SC	93	672	1.4	308	1.4	0.46
	VA	265	1778	1.2	792	1.2	0.45
	WV	110	1147	1.6	653	1.8	0.57

Source: DOE/EERE, 2009

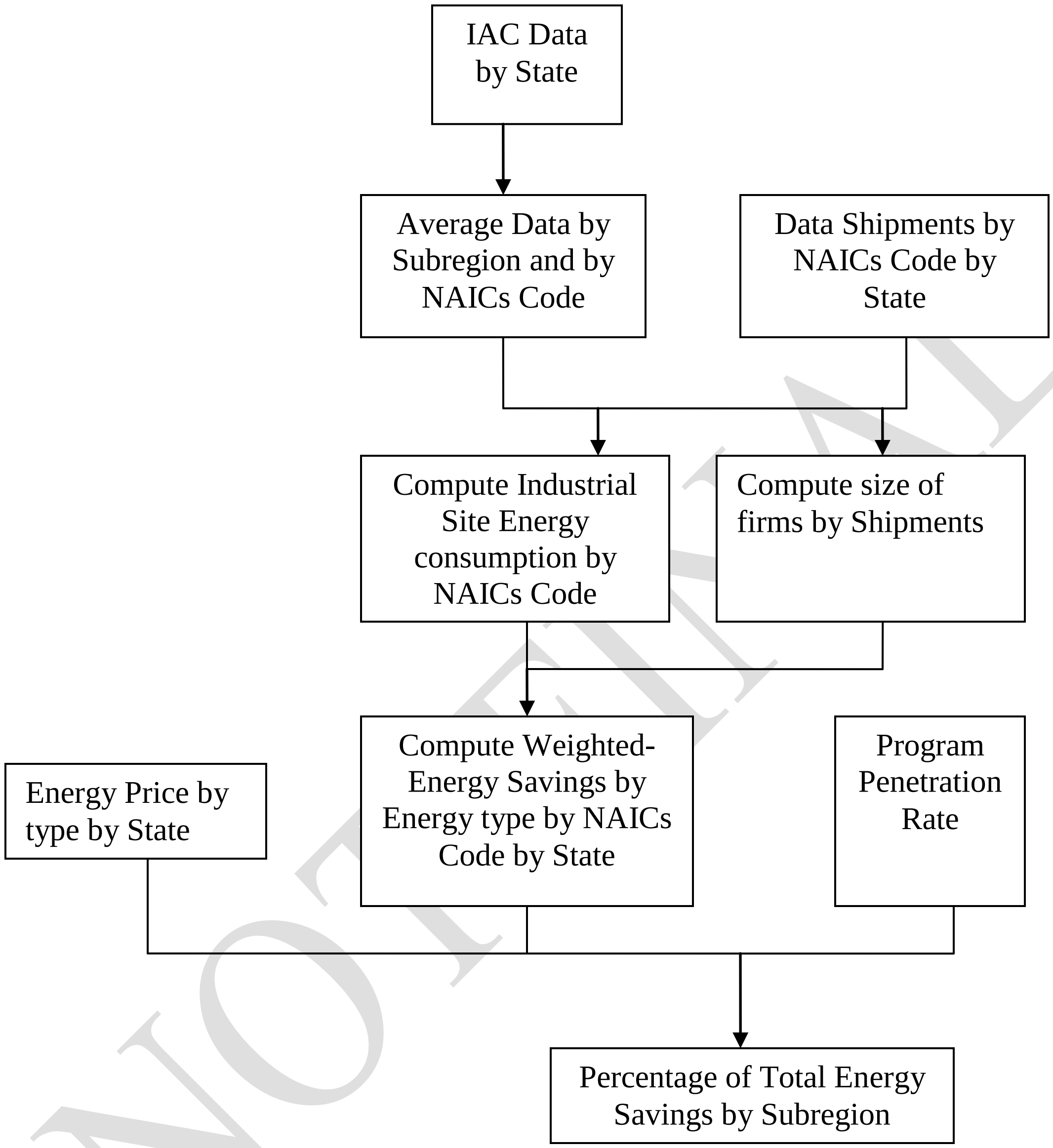

Figure E.1 Information and Process Flow Diagram used to Estimate Industrial Potential Energy Saving IAC

The projections of industrial assessments in the three Census divisions are expected to have a significant increase during the first years of the policy implements. The South Atlantic will need to have 275 assessments in 2013, up for 150 in per year through 2009. The other two divisions require fewer assessments: going from 50 in 2009 in each division to 180 in 2013. The current university partners must provide all of these new assessments, which will require more personnel. Additionally, DOE could include other universities in the region with a capability to conduct these assessments (see Figure E.2).

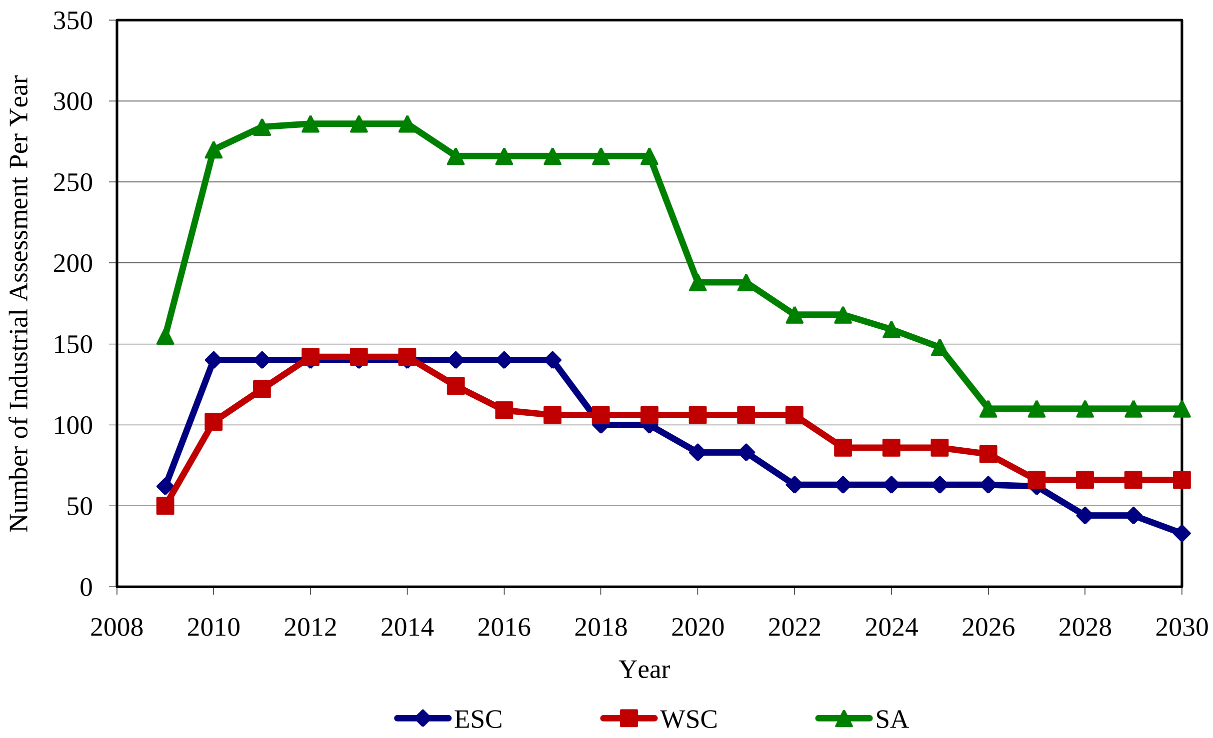

Figure E.2 Projection of IAC Assessments by Census Division in the South Region

The total energy savings expected from the IAC program in the South region is 208 TBtu in 2020. This program, which represents small and medium firms (with 50 to 249 employees) has been considered under this study that represent the 30% of the total value of shipments of the manufacturing industry. The other 70% of shipments is represented by large industries with more than 250 employees (see Table E.2).

Table E.2 Total Annual Energy Efficiency Potential Saving for SMEs Manufacturing Sector in South Region

Region	State	Source Electricity Savings		Natural Gas Savings		Total Energy Savings	Total Energy Savings
		(TBtu)	(%)	(TBtu)	(%)	(TBtu)	(%)
WSC	AK	4.82	27%	2.2	6%	7.04	12%
	LA	14.15	33%	8.4	6%	22.56	12%
	OK	2.17	14%	1.3	5%	3.51	8%
	TX	40.28	28%	23.8	7%	64.04	13%
	Total WSC	*61.42*		*35.74*		*97.16*	
ESC	AL	7.69	23%	3.1	6%	10.75	13%
	KY	9.18	25%	3.2	6%	12.40	14%
	MS	4.10	27%	1.3	6%	5.37	15%
	TN	13.58	30%	4.0	7%	17.59	17%
	Total ESC	*34.56*		*11.55*		*46.11*	
SA	DE	0.70	14%	0.7	13%	1.40	13%
	DC	3.95	21%	2.4	9%	6.37	14%
	Fl	4.95	19%	5.0	15%	9.99	17%
	GA	5.78	15%	6.7	10%	12.44	12%
	MD	1.95	18%	1.6	12%	3.52	15%
	NC	8.56	17%	8.3	14%	16.85	15%
	SC	2.13	16%	2.1	10%	4.20	13%
	VA	3.79	17%	3.9	12%	7.66	14%
	WV	1.05	16%	0.8	13%	1.83	15%
	Total SA	*32.87*		*31.40*		*64.28*	
Total South		*128.85*		*78.70*		*207.55*	

Source: DOE, IAC and Team Analysis

Appendix E.2 Energy Savings Potential from Large Energy Intensive Industrial Firms

Save Energy Now is the program that the Department of Energy (DOE) created in 2006 to assess energy efficiency in large industrial firms (with annual consumption above 1 trillion British thermal units). This study estimates the energy saving for large firms, which represent the 3% of total industrial firms and which consume about 53% of the total annual industrial energy use in the U.S. In the years 2006-2007 a total of 458 assessments were conducted in the U.S., principally in Chemical, food, paper and metal industries (see Figure E.3).

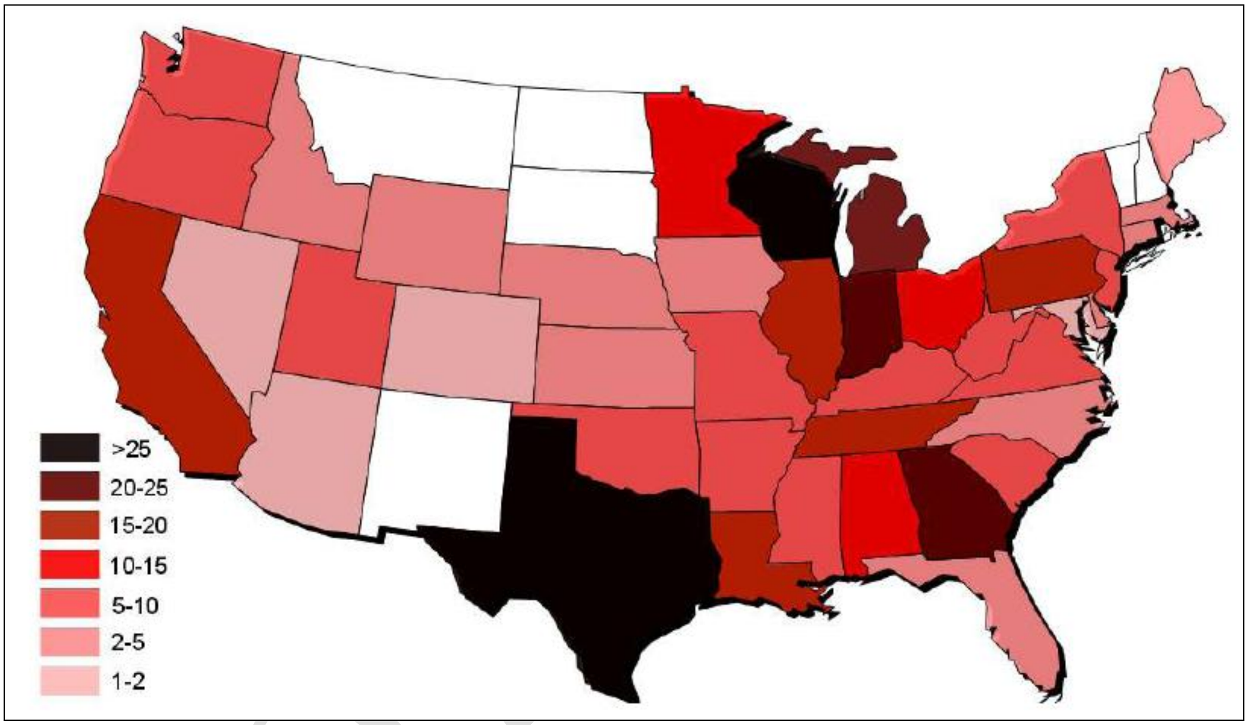

Figure E.3 Distribution of 2006 and 2007 SENA Assessment in U.S.

Results from the U.S. DOE 2007 *Save Energy Now* Assessment Initiative: Summary and Lessons Learned. Oak Ridge National Laboratory, ORNL/TM-2009/075.

Source: Wright A., et al , 2009.

The methodology used to determine large firms' energy saving is based on 253 Save Energy Now assessments conducted in the South during the years 2006 to 2008 from 18 major U.S. industrial groups (chemical, manufacturing, paper, primary metals, food, non-metallic mineral products, and fabricated metal products) (see Table E.3). We used the SENA data by NAICS code and state and combined the set of data to obtain the average energy savings value by sub-region. The energy savings are updated with information about energy cost and employment for each state, considering that large firms have 500 or more employees.

Table E.3 Save Energy Now Assessments in the South			
Census Division	**Number of Assessments 2006**	**Number of Assessments 2007**	**Number of Assessments 2008**
WSC	51	34	22
ESC	27	16	28
SA	19	39	17
Total South	97	89	67

Source: DOE, SENA and Team Analysis

The total number of large industry sites estimated in the South is 6,600. Of these firms 9.8% had an assessment from 2006 to 2008, with projection of about 4.5% of the firms having an assessment each year until 2030 (see Table E.4). The evaluations made to the 2006 and 2007 assessments show that for 2006 a total of 181 (or 90%) of the reported assessments showed after a period of 6 months that the rate of penetration was about 19.3% of recommendations were implemented, another 19.3% of recommendations were in progress, and 31.2% of recommendations were planned under review or awaiting funds for implementation. Assessments conducted in 2007 showed a similar distribution in penetration rate with 15.5% implemented, 14.9% in progress, and 39% planned. In this study we will assume a higher potential rate of penetration at 80%. We assume that the implemented recommendations, plus the recommendations in process and the planned implementation will be done no later than one year after the assessment is conducted for each plant.

Table E.4 Projection of New Save Energy Now Assessments in the South			
Census Division	**Number of Assessments 2010**	**Number of Assessments 2020**	**Number of Assessments 2030**
WSC	83	913	1,646
ESC	83	914	1,647
SA	134	1,470	2,650
Total South	217	2,384	4,298

Source: DOE, SENA and Team Analysis

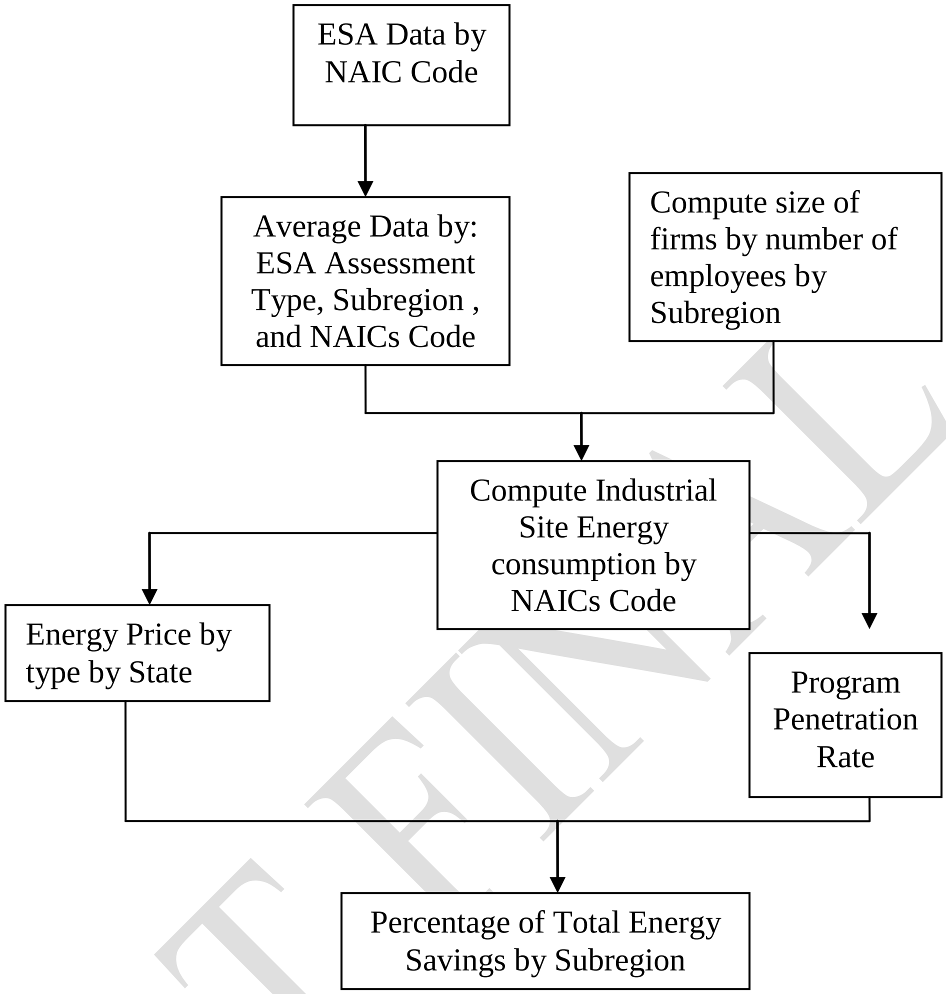

Figure E.4 Information and Process Flow Diagram used to Estimate Industrial Energy Saving SENA

Appendix E.2.1 SNUG-NEMS

The SNUG-NEMS input file ITECH was modified with the information of energy savings by industrial groups for natural gas and electricity (see Table E.5). These two energy sources' savings data helped to adjust the energy intensity use coefficient from the unit energy consumption (UEC) values in the industrial input files of NEMS.

Table E.5 Summary of Energy Savings from IAC and SENA policies

Industry	IAC		SENA		IAC+SENA	
	Electricity	Natural Gas	Electricity	Natural Gas	Electricity	Natural Gas
212 Mining	N/I	N/I	7.3%	6.2%	7.3%	6.2%
311 Food	4.0%	9.8%	7.0%	22.0%	11.0%	31.8%
322 Paper	3.6%	3.4%	16.3%	18.0%	19.9%	21.4%
325 Chemicals	14.0%	7.2%	3.7%	3.5%	17.7%	10.6%
327 Non Metals	5.8%	8.4%	5.3%	3.6%	11.1%	12.0%
331 Iron & Steel	6.7%	7.2%	2.2%	5.2%	8.9%	12.4%
332 Fabricated Metals	11.0%	11.0%	7.6%	7.0%	18.6%	18.0%
333 Machinery	3.8%	3.6%	2.8%	14.4%	6.6%	18.1%
334 Computers & Electronics	10.3%	23.0%	1.1%	0.8%	11.4%	23.8%
336 Transportation Equipment	12.0%	9.3%	4.8%	3.2%	16.8%	12.6%
335 Electrical	7.7%	22.8%	N/I	N/I	7.7%	22.8%
321 Wood	18.2%	1.7%	7.2%	4.6%	25.4%	6.3%
326 Plastics	19.2%	7.6%	4.9%	8.4%	24.2%	16.0%
Others	3.4%	13.8%	2.7%	15.5%	6.1%	29.2%
313 Textile	4.1%	20.7%	5.5%	9.5%	9.6%	30.2%
314 Textile product	2.7%	6.8%	0.0%	21.5%	2.7%	28.3%
324 Petroleum & Coal	0.9%	5.6%	-2.4%	6.0%	-1.5%	11.6%

Due to the fact that IAC and SENA assessments do not provide information for all the industrial groups, such us agriculture and construction, it was not possible to model the energy efficiency potential of these industries.

The Input file "itech.v1.76" was used to modify the Unit Energy Consumption for the industries in the South region, as is shown as an example in the paper industry in the table E.6, where the is an UEC value of for 2030. For example, in the first line the number 8 represents the paper industry, the second number after the comma is 3, which represents the South Region; the following number (1) is the type of process. In the second column the number, 1 represents the type of energy source (electricity in this case). For the next 6 numbers, separated by a comma; the first three numbers shows the old technologies and the next three the new technologies. In the old technology the first number is the UEC in 2002, the second number (1.44184) is the UEC in 2030, which we modify with respect to the reduction in energy intensity obtained from table E.5 for Industrial Assessment for Plant Utility Upgrades policy and the table 5.9 for Industrial Process Improvement Policy. The same modifications were made for the UEC in 2030 to new technologies (1.41426). The third number, which is negative (-0.00502), is the Technology Production Curve (TPC), which in this study we multiply by 2 using the same argument presented in the CEF study (Brown, M., M. Levine, W. Short, and J. Koomey. 2001).

Table E.6 Example of Input File Modification

Industry	Fuel Type	Alteration
8,3,1,'PAPER_M	',1,'ELECTRICITY	',1.66000,1.44184,-0.00502,1.46941,1.41426,-0.00137
8,3,1,'PAPER_M	',3,'NAT GAS CORE	',0.89678,0.77893,-0.00502,0.79382,0.76403,-0.00137
8,3,1,'PAPER_M	,10,'RESIDUAL OIL	',0.16635,0.14449,-0.00502,0.14725,0.14173,-0.00137
8,3,1,'PAPER_M	',11,'DISTILLATE OIL	',0.01623,0.01409,-0.00502,0.01436,0.01382,-0.00137
8,3,1,'PAPER_M	',12,'LPGS HEAT AND POWER	',0.00551,0.00479,-0.00502,0.00488,0.00470,-0.00137
8,3,1,'PAPER_M	',7,'STEAM COAL	',0.05512,0.04788,-0.00502,0.04879,0.04696,-0.00137
8,3,1,'PAPER_M	',31,'STEAM	',5.96000,4.49317,-0.01004,5.27573,4.88685,-0.00273
8,3,2,'BLEACH	'1,'ELECTRICITY	',0.30000,0.23954,-0.00801,0.26346,0.21562,-0.00713
8,3,2,'BLEACH	',31,'STEAM	',4.99000,3.17555,-0.01601,4.38219,2.93102,-0.01426
8,3,3,'WASTE_P	',1,'ELECTRICITY	',1.35000,1.26360,-0.00236,1.26360,1.26360,0.00000
8,3,3,'WASTE_P	',31,'STEAM	'',1.23000,1.07743,-0.00472,1.15128,1.15128,0.00000
8,3,4,'MECH_P	',1,'ELECTRICITY	',5.38000,4.38942,-0.00724,5.00718,3.77167,-0.01007
8,3,4,'MECH_P	',31,'STEAM	',0.44000,0.29245,-0.01448,0.40951,0.23168,-0.02014
8,3,5,'CHEM_P	',1,'ELECTRICITY	',1.45000,1.38349,-0.00168,1.40799,1.35900,-0.00126
8,3,5,'CHEM_P	',31,'STEAM	',4.73000,4.30572,-0.00335,4.59296,4.27872,-0.00253
8,3,6,'KRAFT_P	',1,'ELECTRICITY	',1.45000,1.26215,-0.00494,1.32507,1.19923,-0.00356
8,3,6,'KRAFT_P	',3,'NAT GAS CORE	',1.49464,1.30101,-0.00494,1.36587,1.23615,-0.00356
8,3,6,'KRAFT_P	',10,'RESIDUAL OIL	',0.27726,0.24134,-0.00494,0.25337,0.22931,-0.00356
8,3,6,'KRAFT_P	',11,'DISTILLATE OIL	',0.02704,0.02354,-0.00494,0.02471,0.02237,-0.00356
8,3,6,'KRAFT_P	',12,'LPGS HEAT AND POWER	',0.00919,0.00800,-0.00494,0.00840,0.00760,-0.00356
8,3,6,'KRAFT_P	',7,'STEAM COAL	',0.09187,0.07997,-0.00494,0.08395,0.07598,-0.00356
8,3,6,'KRAFT_P	',31,'STEAM	',10.16000,7.69273,-0.00989,9.28465,7.60214,-0.00712
8,3,7,'WOOD	',1,'ELECTRICITY	',0.27000,0.21375,-0.00831,0.23821,0.18928,-0.00818
8,4,1,'PAPER_M	',1,'ELECTRICITY	',1.66000,1.44184,-0.00502,1.46941,1.41426,-0.00137

Appendix E.3 Industrial Combined Heat and Power

Appendix E.3.1 SNUG-NEMS Input Adjustments in “indcogen”File

(1) End year of ITC: To extend the duration of ITC, CapCostMultEnd is changed from 2008 to 2030.

(2) Installation Cost: To implement a 20% subsidy for installation, the installation cost by system is reduced by 20%.

Table E.6 Total CHP Installation Cost Assumptions (2005$/kw)

Year	IC	IC	GT	GT	GT	GT	GT	Comb. Cycle*
	System 1	System 2	System 3	System 4	System 5	System 6	System 7	System 8
2003	1098	871	1224	944	883	744	644	677
2004	1098	871	1224	944	883	744	644	677
2005	1098	871	1224	944	883	744	644	677
2006	1083	866	1211	930	876	738	640	674
2007	1068	862	1198	917	869	732	636	672
2008	1053	857	1186	903	862	726	632	670
2009	1038	852	1173	890	854	719	628	667
2010	1021	846	1161	877	848	714	626	665
2011	1011	842	1155	871	844	710	624	663
2012	1001	838	1150	866	840	707	622	661
2013	990	834	1144	860	836	704	621	658
2014	980	830	1138	854	832	701	619	656
2015	970	826	1133	849	828	698	618	654
2016	959	822	1127	843	824	694	616	651
2017	949	818	1122	838	820	691	614	649
2018	938	814	1116	832	816	688	613	646
2019	928	810	1110	826	812	685	611	644
2020	919	804	1101	824	808	681	610	645
2021	906	798	1092	820	804	678	608	643
2022	894	792	1083	816	800	674	606	642
2023	881	786	1074	812	796	671	605	640
2024	868	779	1066	808	792	668	603	638
2025	855	773	1057	804	788	665	602	637
2026	842	766	1048	800	784	662	600	635
2027	830	760	1039	796	780	658	598	634
2028	817	754	1030	792	776	655	597	632
2029	804	747	1022	788	772	652	595	630
2030	791	743	1012	783	767	650	594	629

*Two 40MW GT & 20MW ST

(3) Overall Efficiency: To implement a rapid technological development in CHP performance, the overall efficiency is increased by 0.7% annually.

Table E.7 CHP Overall Efficiency

Year	IC	IC	GT	GT	GT	GT	GT	Comb. Cycle*
	System 1	System 2	System 3	System 4	System 5	System 6	System 7	System 8
2003	0.70	0.70	0.69	0.70	0.70	0.70	0.72	0.70
2004	0.70	0.70	0.69	0.70	0.70	0.70	0.72	0.70
2005	0.70	0.70	0.69	0.70	0.70	0.70	0.72	0.70
2006	0.70	0.71	0.69	0.70	0.70	0.71	0.72	0.70
2007	0.70	0.71	0.69	0.70	0.71	0.71	0.72	0.70
2008	0.71	0.71	0.69	0.71	0.71	0.71	0.72	0.70
2009	0.71	0.72	0.69	0.71	0.71	0.71	0.72	0.70
2010	0.72	0.72	0.70	0.71	0.71	0.71	0.72	0.71
2011	0.72	0.73	0.70	0.72	0.72	0.72	0.73	0.71
2012	0.73	0.73	0.71	0.72	0.72	0.72	0.73	0.72
2013	0.73	0.74	0.71	0.73	0.73	0.73	0.74	0.72
2014	0.74	0.74	0.72	0.73	0.73	0.73	0.74	0.73
2015	0.74	0.75	0.72	0.74	0.74	0.74	0.75	0.73
2016	0.75	0.75	0.73	0.74	0.74	0.74	0.75	0.74
2017	0.75	0.76	0.73	0.75	0.75	0.75	0.76	0.74
2018	0.76	0.76	0.74	0.75	0.75	0.75	0.76	0.75
2019	0.76	0.77	0.74	0.76	0.76	0.76	0.77	0.75
2020	0.77	0.77	0.75	0.76	0.76	0.77	0.78	0.76
2021	0.77	0.78	0.75	0.77	0.77	0.77	0.78	0.76
2022	0.78	0.78	0.76	0.77	0.77	0.78	0.79	0.77
2023	0.78	0.79	0.76	0.78	0.78	0.78	0.79	0.77
2024	0.79	0.79	0.77	0.78	0.78	0.79	0.80	0.78
2025	0.79	0.80	0.77	0.79	0.79	0.79	0.80	0.79
2026	0.80	0.81	0.78	0.80	0.80	0.80	0.81	0.79
2027	0.81	0.81	0.78	0.80	0.80	0.80	0.81	0.80
2028	0.81	0.82	0.79	0.81	0.81	0.81	0.82	0.80
2029	0.82	0.82	0.80	0.81	0.81	0.81	0.83	0.81
2030	0.82	0.83	0.80	0.82	0.82	0.82	0.83	0.81

*Two 40MW GT & 20MW ST

Appendix E.3.2 Sensitivity Analysis by Industry

Previous studies say that the bulk chemical, paper, and food industries are the most promising industries for the effectiveness of CHP adoption (Worrell & Price, 2001). Figure E.5 shows the effectiveness of the prime movers of CHP system utilizing the waste heat and steam exhausted from the other manufacturing processes. While no significant difference in the energy consumption is forecast, more electricity and steam are generated under the policy case than the reference case. This means that the plant owners could generate more electricity on site with a minimal increase in natural gas consumption.

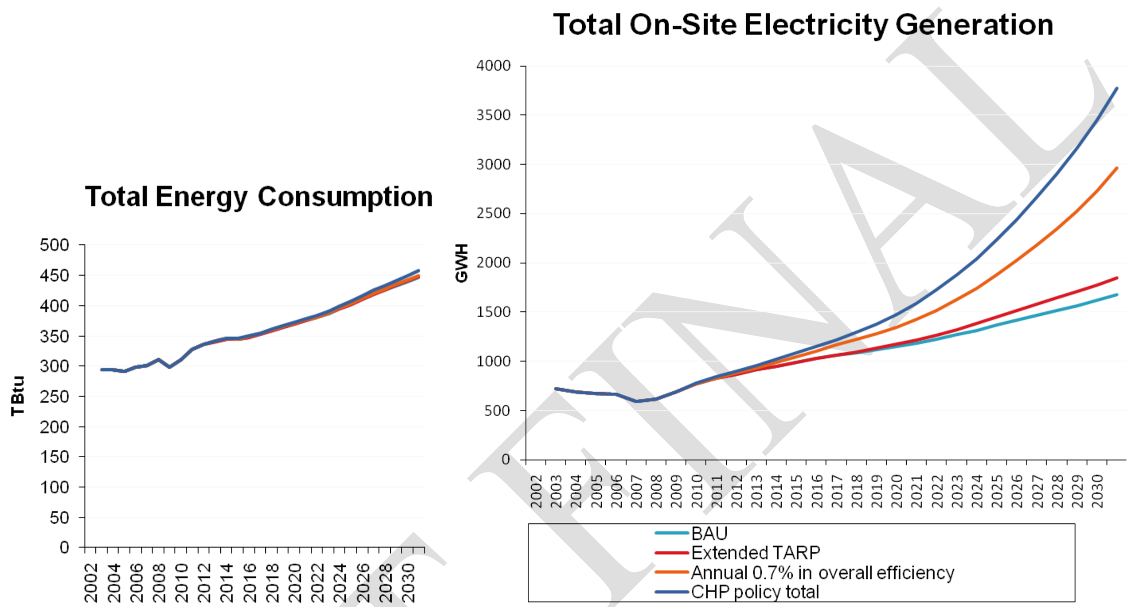

Figure E.5 Energy Consumption & On-Site Electricity Generation Projections in the Food Industry

Appendix E.4 Off-NEMS Calculations for Estimating Potential Energy Savings in the Oil Refinery Industry

In order to model the three industrial energy efficiency policies in SNUG-NEMS, we adjusted variables in the Industrial Sector Demand Module (ISDM) in NEMS. The ISDM contains parameters showing Unit Energy Consumption and Technology Possibility Curve by industry as its major variables, which are used to implement the suggested policies. All of the industries under the scope of this study are treated in the ISDM, but the oil refinery industry is modeled in a different module, named Petroleum Market Module (PMM)[2]. Because 1) the specific industry is modeled in a different location from the rest of the industries and 2) geographical details of outputs from the PMM are not consistent with our definition of the South, we estimated potential savings from the specific industry off NEMS. Based on the pre-analysis with the Excel spreadsheet mentioned above, we estimated the potential savings of the oil refinery industry and compensated for the part that we could not model directly in the SNUG-NEMS.

[2] A source file named *refine.f* contains all of the variables about the oil refinery industry.

Appendix F: Analysis and Results for Energy Efficiency Policy Bundle and Carbon Constrained Future (CCF) Scenarios

Appendix F.1 Per Capita Electricity and Natural Gas Bill Savings in Reference Scenario

Table F.1 Electricity and Natural Gas Bill Savings Per Capita Reference Scenario				
State	**2020**		**2030**	
	(07$/ Capita)	**% Saving**	**(07$/ Capita)**	**% Saving**
AR	310	17%	536	26%
LA	421	17%	665	26%
OK	332	17%	569	26%
TX	306	17%	519	26%
AL	283	14%	501	23%
KY	296	14%	523	23%
MS	243	14%	434	23%
TN	228	14%	423	23%
DC	413	15%	731	25%
DE	246	15%	415	25%
FL	202	15%	365	25%
GA	254	15%	430	25%
MD	213	15%	367	25%
NC	234	15%	405	25%
SC	276	15%	464	25%
VA	246	15%	426	25%
WV	349	15%	701	25%

Appendix F.2 Analysis and Results in Carbon Constrained Future Scenario

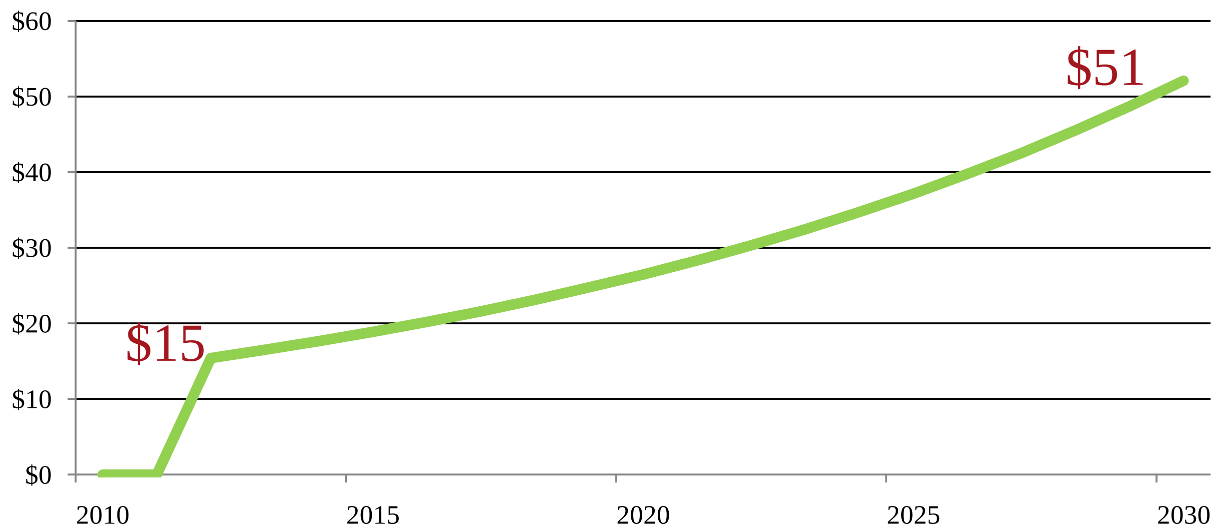

Figure F.1 Carbon Allowance Price Over Years (in 2005$ per metric ton of CO_2)

Table F.2 Electricity and Natural Gas Bill Savings Per Capita CCF				
State	**2020**		**2030**	
	(07$/ Capita)	**% Saving**	**(07$/ Capita)**	**% Saving**
AR	288	15%	411	17%
LA	376	15%	453	17%
OK	307	15%	432	17%
TX	280	15%	383	17%
AL	284	14%	469	19%
KY	299	14%	495	19%
MS	243	14%	403	19%
TN	232	14%	405	19%
DC	465	17%	653	20%
DE	274	17%	372	20%
FL	234	17%	328	20%
GA	284	17%	387	20%
MD	238	17%	334	20%
NC	265	17%	365	20%
SC	312	17%	420	20%
VA	277	17%	384	20%
WV	385	17%	628	20%

Appendix F.3 Macroeconomic Calculations Methodology with ACEEE Spreadsheet Application

The calculations for change in Gross State/Regional Product (GSP/GRP) and additional employment from the nine energy efficiency policies used an input-output (I-O) calculation method developed for this report by the American Council for an Energy Efficient Economy (ACEEE) (Laitner and Knight, 2009). Table F.2 is the I-O spreadsheet for a single sample year. The inputs are in cells D2, D3, D4, D6 and D7 are from the integrated SNUG-NEMS results for the region (For the state-by-state calculations, the research teams used the apportioned values by state). D2, D3 and D4 are investment costs, while D6 and D7 are from the reductions in electricity demand.

To determine the Key Impact Coefficients, the research team aggregated and modeled with IMPLAN Version 3.0 (IMPLAN, 2009). The 17 data sets analyzed in this study were for the sixteen states and the District of Columbia for 2008. For the region-wide calculations, the IMPLAN software allowed the researchers to aggregate the data sets to generate one set of region-wide coefficients. Table F.3 shows the IMPLAN sector aggregations for this report. The Construction and Energy Efficiency Equipment sector is the source of the direct growth for the investments in energy efficiency. The Electricity and Natural Gas sectors decline due to a decrease in consumption, while the other sectors of the economy also benefit from increased demand as consumers and businesses have increased capital to purchase items other than energy. Tables F.4 and F.5 show the key impact coefficients generated in the IMPLAN modeling (IMPLAN, 2009).

Tables F.6 and F.7 show the output from the I-O calculations. At the state level, the GSP and employment totals were adjusted for imputed demand after the I-O calculations because simply employing the calculator produced a 17 state total that was $2.3 billion dollars of GSP and 169,400 jobs lower than the regional- coefficient total in 2020 and $3.4 billion of GSP and 201,700 jobs lower in 2030. These differences were the result of spillover and cross-border trade among the states in the region. To account for this difference, we added the imputed demand across states using the methods of Pollin, Wicks-Lim & Garrett-Peltier (2009) and redistributed the differences based on the state's share of the 2007 GRP (Bureau of Economic Analysis, 2008).

	A	B	C	D
1	**Spending Patterns (in Millions of 2008 dollars)**			**YEAR**
2	Program and Admin Costs (Other than Incentives)			D2
3	Incentives to Stimulate Overall Productive Investment			D3
4	Productive Investment from Private Sector and/or Households			D4
5	Total Productive Investment			*D4+D3*
6	Change in Electricity Demand			D6
7	Change in Natural Gas Demand			D7
8				
9	**Key Impact Coefficients (Total Jobs/$MM; Value-added/$)**	**Jobs**	**GSP**	
10	Construction and EE Equipment	B10	C10	
11	Electricity	B11	C11	
12	Natural Gas	B12	C12	
13	Other	B13	C13	
14				
15	Annual Rate of Labor Productivity	B15		
16	**Implied Change in Final Demand (Millions of 2008 Dollars)**			**YEAR**
17	Construction and EE Equiptment			*D4+D3*
18	Electricity			D6
19	Natural Gas			D7
20	Other			*-D20-D19-D2-D5*
21				
22	**Suggested Macroeconomic Impacts**			**YEAR**
23	**ACEEE Jobs (actual)**			*SUMPRODUCT(D$17:D$20,$B$10:$B$13)/(1+$B15)^(D1-2008)*
24	ACEEE GSP (Million 2008 Dollars)			*SUMPRODUCT(D$17:D$20,$C$10:$C$13)*
25	**ACEEE GSP (Million 2007 Dollars)**			*D24/1.04*

Figure F.2 ACEEE Input-Output Calculator for a Single Year

Sources of Data

D2, D3, D4, D6, D7 = SNUG-NEMS Results (Please note that values are converted from 2007$ to 2008$ before entry and D6 and D7 are negative due to declines in electricity and natural gas demand from the policies).

B10, B11, B12, B13, C10, C11, C12, C13= IMPLAN Coefficients

B15= 1.9% (from the Bureau of Labor Statistics (2009)).

Table F.3 Aggregation of Sectors for ACEEE Calculator		
Category	**IMPLAN Code**	**Description**
Construction and Energy Efficiency Equipment	34	Construction of new nonresidential commercial and health care structures
	35	Construction of new nonresidential manufacturing structures
	36	Construction of other new nonresidential structures
	37	Construction of new residential permanent site single- and multi-family structures
	38	Construction of other new residential structures
	39	Maintenance and repair construction of nonresidential structures
	40	Maintenance and repair construction of residential structures
	205	Construction machinery manufacturing
	216	Air conditioning, refrigeration, and warm air heating equipment manufacturing
	259	Electric lamp bulb and part manufacturing
	260	Lighting fixture manufacturing
	261	Small electrical appliance manufacturing
	262	Household cooking appliance manufacturing
	263	Household refrigerator and home freezer manufacturing
	264	Household laundry equipment manufacturing
	265	Other major household appliance manufacturing
	322	Retail Stores - Electronics and appliances
Electricity	21	Mining coal
	31	Electric power generation, transmission, and distribution
	428	Federal electric utilities
Natural Gas	32	Natural Gas
Other	ALL	Other sectors of the economy

Table F.4 Gross State/Regional Product Coefficients: Value Added Per Dollar of Productive Investment				
State	**Construction and EE Equipment**	**Electricity**	**Natural Gas**	**Other**
Alabama	$0.65	$0.91	$0.56	$0.73
Arkansas	$0.70	$0.84	$0.59	$0.77
Delaware	$0.84	$0.96	$0.68	$0.87
District of Columbia	$0.92	$0.97	$0.82	$1.04
Florida	$1.08	$1.07	$0.91	$1.11
Georgia	$0.91	$1.01	$0.81	$0.97
Kentucky	$0.69	$0.80	$0.55	$0.75
Louisiana	$0.74	$0.92	$0.60	$0.72
Maryland	$1.02	$1.03	$0.90	$1.07
Mississippi	$0.62	$0.88	$0.48	$0.69
North Carolina	$0.81	$0.96	$0.68	$0.89
Oklahoma	$0.72	$0.95	$0.70	$0.83
South Carolina	$0.74	$0.95	$0.62	$0.83
Tennessee	$0.79	$0.70	$0.69	$0.87
Texas	$0.95	$1.01	$0.90	$0.95
Virginia	$0.96	$1.01	$0.84	$1.03
West Virginia	$0.70	$0.82	$0.55	$0.74
SOUTH REGION	$1.09	$1.08	$0.98	$1.10

Table F.5 Employment Coefficients: Jobs per Million Dollars in Productive Investment				
State	**Construction and EE Equipment**	**Electricity**	**Natural Gas**	**Other**
Alabama	13.13	4.06	5.90	11.71
Arkansas	12.91	4.68	5.74	11.26
Delaware	12.62	3.72	5.78	10.30
District of Columbia	10.42	3.05	4.95	8.20
Florida	17.36	5.52	10.02	15.31
Georgia	14.65	4.17	6.92	12.44
Kentucky	11.88	5.74	5.86	11.12
Louisiana	12.27	3.30	5.15	9.28
Maryland	13.73	3.56	6.50	12.55
Mississippi	12.66	4.14	5.91	11.56
North Carolina	14.38	4.28	7.21	12.25
Oklahoma	12.58	3.53	5.13	10.77
South Carolina	13.63	4.46	6.65	12.58
Tennessee	13.05	6.81	6.64	11.98
Texas	13.16	3.19	5.11	10.12
Virginia	14.23	4.36	6.60	12.13
West Virginia	12.35	5.63	5.30	11.34
SOUTH REGION	16.45	5.63	8.43	13.86

Table F.6 Change in Gross State/Regional Product from Energy Efficiency Policy Investment			
State	**Percent of Regional GSP (2007)**	**2020**	**2030**
Alabama	3.51%	-$60	-$77
Arkansas	2.03%	$10	$34
Delaware	1.29%	$12	$17
District of Columbia	1.87%	$55	$76
Florida	15.79%	$534	$937
Georgia	8.53%	$80	$111
Kentucky	3.27%	-$27	-$28
Louisiana	3.72%	$128	$248
Maryland	5.61%	$164	$267
Mississippi	1.82%	-$91	-$137
North Carolina	8.47%	$11	-$16
Oklahoma	2.68%	-$61	-$68
South Carolina	3.25%	-$66	-$115
Tennessee	5.39%	$187	$413
Texas	23.36%	$177	$168
Virginia	8.25%	$189	$313
West Virginia	1.16%	-$10	-$26
Total	100.00%	$1,231	$2,115

Table F.7 Additional Employment from Productive Investment in Energy Efficiency Policy			
State	**Percent of Regional GSP**	**2020**	**2030**
Alabama	3.51%	12,000	16,100
Arkansas	2.03%	10,700	14,700
Delaware	1.29%	3,700	4,700
District of Columbia	1.87%	4,200	5,200
Florida	15.79%	65,300	96,400
Georgia	8.53%	32,900	44,400
Kentucky	3.27%	9,800	13,200
Louisiana	3.72%	21,700	28,800
Maryland	5.61%	19,500	26,200
Mississippi	1.82%	6,500	8,900
North Carolina	8.47%	31,500	43,400
Oklahoma	2.68%	11,700	15,500
South Carolina	3.25%	13,700	18,200
Tennessee	5.39%	15,100	20,700
Texas	23.36%	87,900	117,600
Virginia	8.25%	29,200	39,300
West Virginia	1.16%	5,100	6,900
Total	100.00%	380,500	520,200

Table F.8 GSP in Millions 2007$							
State	**Percent Regional GSP**	**2020 (without Imputed Demand)**	**Imputed Demand**	**2020**	**2030 (without Imputed Demand)**	**Imputed Demand**	**2030**
Alabama	3.51%	-$96	$80	**-$16**	-$125	$118	**-$7**
Arkansas	2.03%	-$106	$46	**-$60**	-$154	$68	**-$86**
Delaware	1.29%	-$19	$29	**$10**	-$29	$43	**$14**
District of Columbia	1.87%	$10	$43	**$52**	$10	$63	**$72**
Florida	15.79%	$154	$360	**$514**	$375	$530	**$905**
Georgia	8.53%	-$125	$195	**$70**	-$192	$286	**$94**
Kentucky	3.27%	-$58	$75	**$17**	-$58	$110	**$52**
Louisiana	3.72%	-$77	$85	**$8**	-$125	$125	**$0**
Maryland	5.61%	$29	$128	**$157**	$67	$188	**$256**
Mississippi	1.82%	-$106	$41	**-$65**	-$163	$61	**-$102**
North Carolina	8.47%	-$192	$193	**$1**	-$317	$284	**-$33**
Oklahoma	2.68%	-$125	$61	**-$64**	-$163	$90	**-$74**
South Carolina	3.25%	-$144	$74	**-$70**	-$231	$109	**-$122**
Tennessee	5.39%	$106	$123	**$229**	$298	$181	**$479**
Texas	23.36%	-$250	$533	**$283**	-$394	$784	**$390**
Virginia	8.25%	-$10	$188	**$178**	$19	$277	**$296**
West Virginia	1.16%	-$38	$27	**-$12**	-$67	$39	**-$28**
Total	100%	-1,049	2,280	**1,231**	-1,250	3,365	**2,115**

Table F.9 Additional GSP Coefficients (Value Added Per Dollar)				
State	**Construction and EE Equipment**	**Electricity**	**Natural Gas**	**Other**
Alabama	$0.65	$0.91	$0.56	$0.73
Arkansas	$0.70	$0.84	$0.59	$0.77
Delaware	$0.84	$0.96	$0.68	$0.87
District of Columbia	$0.92	$0.97	$0.82	$1.04
Florida	$1.08	$1.07	$0.91	$1.11
Georgia	$0.91	$1.01	$0.81	$0.97
Kentucky	$0.69	$0.80	$0.55	$0.75
Louisiana	$0.74	$0.92	$0.60	$0.72
Maryland	$1.02	$1.03	$0.90	$1.07
Mississippi	$0.62	$0.88	$0.48	$0.69
North Carolina	$0.81	$0.96	$0.68	$0.89
Oklahoma	$0.72	$0.95	$0.70	$0.83
South Carolina	$0.74	$0.95	$0.62	$0.83
Tennessee	$0.79	$0.70	$0.69	$0.87
Texas	$0.95	$1.01	$0.90	$0.95
Virginia	$0.96	$1.01	$0.84	$1.03
West Virginia	$0.70	$0.82	$0.55	$0.74
Total	$1.09	$1.08	$0.98	$1.10

Table F.10 Electricity, Natural Gas and Total Energy Savings by State (Million 2007$)						
State	**Electricity Savings (millions 07$)**		**Natural Gas Savings (millions 07$)**		**Total Energy Savings (millions 07$)**	
	2020	**2030**	**2020**	**2030**	**2020**	**2030**
DC	$167	$257	$16.9	$24.0	$405	$597
DE	$200	$348	$33.4	$47.0	$376	$631
FL	$3,870	$8,070	$549	$985	$7,450	$14,900
GA	$2,070	$3,820	$341	$513	$3,838	$6,831
MD	$1,100	$2,000	$166	$255	$2,067	$3,630
NC	$2,010	$3,850	$313	$498	$3,790	$7,000
SC	$994	$1,740	$178	$248	$1,800	$3,040
VA	$1,820	$3,370	$272	$421	$3,550	$6,330
WV	$492	$931	$92.4	$137	$875	$1,600
AL	$886	$1,610	$385	$676	$1,320	$2,350
KY	$825	$1,500	$358	$628	$1,230	$2,180
MS	$485	$880	$190	$330	$703	$1,250
TN	$1,130	$2,230	$404	$751	$1,600	$3,080
AR	$560	$994	$277	$491	$1,160	$1,750
LA	$1,050	$1,750	$1,080	$1,860	$3,660	$4,760
OK	$746	$1,314	$340	$597	$1,470	$2,220
TX	$5,270	$10,200	$3,630	$7,120	$13,700	$21,500

Appendix G: Calculations and Baseline Projections for State Profiles

Individual state profiles for the Southern states can be found on the Southeast Energy Efficiency Alliance website (http://www.seealliance.org/programs/se-efficiency-study.php). Several calculations were conducted for the state profiles. First, all of the data was proportioned from the census division data to state data using the proportions generated from historical state to census division energy consumption and projected population.

Table G.1 shows the information for the calculation of the increase in projected consumption from 2030 from 2010 projected consumption levels. The baseline consumption is an altered AEO 2009 baseline where the electricity related losses is calculated using a factor of 2.159 for the residential, commercial, and industrial sectors.

Table G.1 Percentage Increase of Projected Consumption in 2030 from 2010 Consumption

State	Baseline Consumption in 2010 (Quad)	Baseline Consumption in 2030 (Quad)	% Increase of Projected Consumption in 2030 from 2010
AL	2.037	2.094	3%
AR	1.144	1.171	2%
DC	0.176	0.144	-18%
DE	0.294	0.310	6%
FL	4.631	6.487	40%
GA	3.120	3.60	15%
KY	1.859	1.955	5%
LA	3.185	2.852	-10%
MD	1.508	1.673	11%
MS	1.118	1.153	3%
NC	2.721	3.307	22%
OK	1.493	1.485	0%
SC	1.651	1.743	6%
TN	2.170	2.504	15%
TX	11.337	13.586	20%
VA	2.495	2.855	14%
WV	0.768	0.921	20%

The projected decrease in the projected baseline due to the energy efficiency savings were calculated for 2020 and 2030 for each of the three sectors (Table G.2).

Table G.2 Percentage Decrease of Projected Baseline Consumption from Energy Efficiency

State	Commercial		Industrial		Residential		Total	
	% decrease in 2020	% decrease in 2030	% decrease in 2020	% decrease in 2030	% decrease in 2020	% decrease in 2030	% decrease in 2020	% decrease in 2030
DC	13.25%	20.45%	5.90%	7.27%	12.22%	18.89%	11.58%	17.77%
DE	13.20%	20.37%	21.03%	37.82%	10.46%	16.14%	10.25%	16.78%
FL	13.76%	21.13%	5.90%	7.27%	9.81%	15.11%	7.32%	11.42%
GA	13.55%	20.86%	5.90%	7.27%	10.90%	16.73%	6.87%	10.39%
MD	12.83%	19.84%	5.90%	7.27%	10.92%	16.85%	7.47%	11.20%
NC	13.58%	20.89%	5.90%	7.27%	10.24%	15.74%	7.26%	10.98%
SC	13.59%	20.92%	5.90%	7.27%	10.24%	15.75%	7.03%	10.30%
VA	13.41%	20.64%	8.40%	12.08%	10.48%	16.16%	7.48%	11.55%
WV	12.70%	19.71%	9.85%	14.50%	11.05%	16.98%	6.97%	10.48%
AL	11.96%	18.23%	11.21%	17.91%	8.20%	12.47%	8.75%	14.40%
KY	11.72%	17.94%	9.18%	13.27%	8.53%	13.08%	7.36%	11.45%
MS	11.40%	17.53%	17.76%	31.02%	8.17%	12.46%	10.40%	17.77%
TN	11.58%	17.76%	9.63%	13.89%	7.60%	11.35%	6.60%	10.33%
AR	13.15%	19.80%	13.02%	19.31%	9.65%	14.42%	7.91%	11.58%
LA	13.80%	20.62%	15.79%	27.26%	9.42%	13.97%	13.85%	22.90%
OK	13.36%	20.08%	18.12%	29.99%	10.04%	15.11%	11.38%	17.36%
TX	13.61%	20.39%	14.33%	20.29%	9.40%	13.95%	9.42%	13.32%

The percentage of the estimated savings in 2020 and 2030 of the total energy consumed by the state in 2007 was calculated (Table G.3). The historical 2007 energy consumption is from the State Energy Data System of the EIA.

Table G.3 Percentage Savings of 2007 Energy Consumption for Total Sector

State	Historical TBtu in 2007	Savings by 3 Sectors by State (TBtu) in 2020	Savings by 3 Sectors by State (TBtu) in 2030	% savings of 2007 consumption in 2020	% savings of 2007 consumption in 2030
DE	302.0	31.3	52.1	10.37%	17.24%
DC	187.2	18.2	25.6	9.73%	13.67%
FL	4,601.9	393.5	741.0	8.55%	16.10%
GA	3,133.0	230.8	374.0	7.37%	11.94%
MD	1,488.7	118.3	187.3	7.95%	12.58%
NC	2,700.0	216.0	363.0	8.00%	13.45%
SC	1,692.3	119.7	179.6	7.07%	10.62%
VA	2,610.9	198.6	329.7	7.60%	12.63%
WV	850.5	57.9	96.5	6.81%	11.34%
AL	2,132.0	183.1	301.6	8.59%	14.15%
KY	2,023.0	142.7	223.9	7.06%	11.07%
MS	1,239.5	119.7	204.8	9.66%	16.52%
TN	2,330.5	154.5	258.7	6.63%	11.10%
AR	1,149.3	92.3	135.6	8.03%	11.80%
LA	3,766.2	425.2	653.1	11.29%	17.34%
OK	1,608.5	169.6	257.8	10.55%	16.03%
TX	11,834.5	1,180.3	1,809.6	9.97%	15.29%

Table G.4 shows the information for the power plant equivalencies calculations using the total primary electricity savings estimated for each state. The total primary electricity savings was the sum of the electricity savings and the avoided electricity related losses (ERL). This calculation was conducted using the conversion of thirty 500 MW power plants approximated by 1 EJ, as defined by Koomey et al. (2009).

Table G.4 Primary Electricity Savings with Power Plant Equivalencies

State	Electricity & ERL Saved in 2020	Electricity & ERL Saved in 2030	Total (quads) in 2020	Total (quads) in 2030	Total (EJ) in 2020	Total (EJ) in 2030	Power Plants in 2020	Power Plants in 2030
DE	20.02	32.99	0.02	0.03	0.02	0.03	0.63	1.04
DC	15.04	21.49	0.02	0.02	0.02	0.02	0.48	0.68
FL	380.48	727.31	0.38	0.73	0.40	0.77	12.04	23.02
GA	197.04	330.32	0.20	0.33	0.21	0.35	6.24	10.45
MD	93.37	153.06	0.09	0.15	0.10	0.16	2.96	4.84
NC	193.02	335.04	0.19	0.34	0.20	0.35	6.11	10.60
SC	107.88	169.72	0.11	0.17	0.11	0.18	3.41	5.37
VA	166.29	282.72	0.17	0.28	0.18	0.30	5.26	8.95
WV	47.43	81.99	0.05	0.08	0.05	0.09	1.50	2.59
AL	135.15	222.60	0.14	0.22	0.14	0.23	4.28	7.05
KY	118.29	188.72	0.12	0.19	0.12	0.20	3.74	5.97
MS	71.25	119.92	0.07	0.12	0.08	0.13	2.26	3.80
TN	135.60	232.33	0.14	0.23	0.14	0.25	4.29	7.35
AR	64.82	102.25	0.06	0.10	0.07	0.11	2.05	3.24
LA	183.85	318.53	0.18	0.32	0.19	0.34	5.82	10.08
OK	95.58	156.62	0.10	0.16	0.10	0.17	3.03	4.96
TX	668.24	1,166.35	0.67	1.17	0.70	1.23	21.15	36.92

The household equivalencies were calculated by state using the residential sector energy savings (See Table G.5). The historical residential energy consumption in 2007 by each state was obtained from the State Energy Data System of the EIA. The estimated number of households was obtained from the Census Bureau. The inverse energy consumption per household was calculated from these values (estimated households divided by TBtu in 2007). The residential energy consumption per state was then multiplied by this number to obtain the household equivalencies.

Table G.5 Residential Savings, Historical Consumption, and Equivalencies

State	Historic TBtu in 2007*	Savings by State (TBtu) in 2020	Savings by State (TBtu) in 2030	Households 2006-2008 ACS 3-yr Estimates	Household divided by TBtu in 2007	Households in 2020	Households in 2030
DE	66.8	7.20	11.46	325,746	4,876.4	35,112	55,898
DC	37.1	3.48	4.70	250,423	6,749.9	23,511	31,702
FL	1339.5	158.20	301.80	7,080,705	5,286.1	836,238	1,595,321
GA	744.4	88.04	149.04	3,421,866	4,596.8	404,703	685,113
MD	425.6	48.20	78.99	2,086,828	4,903.3	236,345	387,286
NC	715.9	78.97	138.37	3,533,366	4,935.6	389,745	682,939
SC	359	37.62	61.94	1,686,571	4,698.0	176,760	290,970
VA	628.4	67.82	114.03	2,931,657	4,665.3	316,409	531,964
WV	163.6	19.43	34.28	742,527	4,538.7	88,187	155,590
AL	405.5	36.43	60.34	1,811,009	4,466.1	162,686	269,479
KY	372.6	34.90	57.80	1,666,775	4,473.4	156,117	258,566
MS	234.4	20.96	34.29	1,079,088	4,603.6	96,482	157,847
TN	546.2	41.50	72.06	2,408,031	4,408.7	182,948	317,692
AR	228.6	23.10	36.04	1,106,185	4,839.0	111,773	174,383
LA	356.4	34.38	51.38	1,590,100	4,461.6	153,374	229,243
OK	306.2	30.82	47.69	1,399,079	4,569.2	140,813	217,903
TX	1594.1	182.83	312.62	8,258,094	5,180.4	947,122	1,619,486

*From EIA State Energy Data System

The average industrial facility equivalencies were calculated by state using the industrial sector energy savings (See table G.6). The estimated number of industrial facilities per TBtu of energy was estimated to be 0.69 and calculated from IAC and SENA data. The equivalent average industrial facilities were calculated by multiplying the industrial energy savings per state by the factor.

Table G.6 Industrial Savings, Historical Consumption, and Equivalencies

State	Historical TBtu in 2007*	Savings (Tbtu) in 2020	Savings (Tbtu) in 2030	Average Industrial Facilities in 2020	Average Industrial Facilities in 2030
DE	101.1	15.31	25.98	22	37
DC	4	0.26	0.26	0.37	0.37
FL	558.9	29.92	40.55	43	58
GA	887.4	48.44	59.37	70	85
MD	184	21.48	25.67	31	37
NC	643.7	42.25	53.35	61	77
SC	620.9	41.19	48.63	59	70
VA	567.4	37.05	52.71	53	76
WV	396.1	21.33	30.76	31	44
AL	941.6	98.30	157.77	141	227
KY	891.6	70.29	101.50	101	146
MS	454.1	84.09	145.69	121	210
TN	740.1	63.46	96.74	91	139
AR	463.7	44.78	60.67	64	87
LA	2403.8	348.59	537.05	501	773
OK	588.3	103.11	153.65	148	221
TX	5950.9	745.16	1,054.86	1,072	1,517

*From EIA State Energy Data System

The average Wal-Mart equivalencies were calculated per state using the commercial sector energy savings (See Table G.7). The energy consumed by a Wal-Mart store was found to be 96.5 MBtu/day from Courtemanch and Bensheimer (2005). This was converted to energy consumption per year. The industrial energy savings per state was divided by the energy consumed by a Wal-Mart store per year to obtain the estimated number of average Wal-Marts.

Table G.7 Commercial Savings, Historical Consumption, and Equivalencies

State	Historical TBtu in 2007*	Savings (Tbtu) in 2020	Savings (Tbtu) in 2030	Average Wal-Marts in 2020	Average Wal-Marts in 2030
DE	124.6	8.81	14.61	250	415
DC	58.4	14.48	20.64	411	586
FL	1,089.20	205.40	398.66	5,832	11,318
GA	565.7	94.30	165.58	2,677	4,701
MD	416.4	48.64	82.69	1,381	2,348
NC	573.5	94.78	171.30	2,691	4,863
SC	263.5	40.85	69.07	1,160	1,961
VA	600.5	93.67	162.97	2,660	4,627
WV	111.5	17.17	31.43	487	892
AL	280.6	48.37	83.47	1,373	2,370
KY	260.9	37.56	64.57	1,066	1,833
MS	175	14.65	24.78	416	704
TN	386.7	49.52	89.91	1,406	2,553
AR	161.9	24.38	38.93	692	1,105
LA	292.3	42.22	64.66	1,199	1,836
OK	250.3	35.72	56.42	1,014	1,602
TX	1,381.60	252.30	442.09	7,163	12,551

*From EIA State Energy Data System

The energy bill savings for each sector was also calculated (See Table G.8 for results). This was done by taking the total sector energy savings and dividing it by the estimated number of total businesses, industries, or residents.

Table G.8 Energy Bill Savings by Sector, 2020

State	Commercial Bill Savings per Average Business in 2020	Industrial Bill Savings per Average Industrial Facility in 2020	Residential Bill Savings per Household in 2020
AL	$15,958	$114,279	$245
AR	$21,360	$184,772	$303
DC	$193,390	$35,377	$167
DE	$57,853	$70,413	$316
FL	$65,955	$19,543	$328
GA	$63,137	$48,035	$337
KY	$18,408	$126,893	$242
LA	$24,097	$807,461	$320
MD	$65,625	$37,087	$311
MS	$15,394	$97,626	$238
NC	$64,696	$31,193	$319
OK	$26,678	$172,724	$308
SC	$52,363	$64,210	$313
TN	$19,809	$72,669	$264
TX	$31,479	$404,143	$328
VA	$79,658	$44,268	$325
WV	$65,434	$114,995	$344

Additional economic calculations were performed using the ACEEE calculator as described in Appendix F. Also refer to Appendix F for the tables regarding State Gross Product and employment arising from the energy savings from energy efficiency.

The energy consumption projections by state may be of use for other researchers and studies. Because of this, the baseline consumption projections from NEMS that have been proportioned to the state level are provided in Table G.9 – G. 11. These include information for electricity and natural gas consumption in the commercial, industrial, and residential sectors. Electricity data is provided as the projected growth in electricity consumption only (Table G.9). Electricity related losses are provided in Table G.10, which when added to the electricity consumption produces the total primary electricity consumption. Electricity related losses are not projections from NEMS, but are calculated using the factor of 2.159 mentioned previously. All values are rounded to three significant digits. Be aware that the sum of the commercial, industrial, and residential sectors does not constitute the total energy consumption projection per state since the transportation sector is not included.

Table G.9 Baseline Projections for Electricity Consumption by Southern State and Sector, 2010-2030 (TBtu)

State	Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
DC	COM	31.3	31.1	30.7	30.4	30.2	30.1	29.9	29.7	29.5	29.3	29.1	28.9	28.7	28.5	28.3	28.2	28.0	27.8	27.6	27.4	27.3
	IND	0.72	0.72	0.73	0.73	0.71	0.69	0.67	0.66	0.64	0.63	0.62	0.60	0.59	0.57	0.56	0.55	0.53	0.51	0.50	0.48	0.46
	RES	5.87	5.81	5.75	5.60	5.51	5.44	5.38	5.32	5.27	5.23	5.18	5.12	5.07	5.04	5.01	4.97	4.94	4.90	4.86	4.80	4.74
DE	COM	15.7	15.9	16.0	16.1	16.3	16.6	16.8	17.0	17.2	17.4	17.5	17.7	17.9	18.1	18.2	18.4	18.6	18.8	18.9	19.0	19.1
	IND	9.99	10.2	10.5	10.7	10.6	10.5	10.4	10.4	10.4	10.3	10.3	10.2	10.1	10.0	9.98	9.89	9.76	9.58	9.40	9.20	9.03
	RES	15.2	15.3	15.4	15.3	15.4	15.4	15.6	15.7	15.8	16.0	16.1	16.2	16.3	16.5	16.6	16.8	16.9	17.0	17.1	17.1	17.2
FL	COM	350	357	364	370	379	388	398	407	417	427	437	447	458	470	481	494	507	519	531	543	556
	IND	62.3	64.5	66.7	68.6	68.8	68.5	68.8	69.5	70.3	70.8	71.5	72.0	72.3	73.0	73.6	74.2	74.4	74.1	73.9	73.5	73.3
	RES	414	422	429	429	435	442	451	459	469	480	490	499	510	523	537	549	563	576	588	598	609
GA	COM	170	172	174	176	179	182	185	188	191	194	197	199	202	206	209	212	215	218	221	224	226
	IND	108	112	115	117	117	115	115	115	116	116	116	116	115	115	115	114	114	112	111	109	107
	RES	186	188	190	189	191	192	194	197	199	202	205	206	209	212	216	219	222	224	227	228	230
MD	COM	81.5	82.5	83.2	83.9	85.0	86.3	87.5	88.6	89.8	90.9	92.0	93.0	94.2	95.4	96.6	97.8	99.1	100	101	102	103
	IND	49.4	50.7	52.0	52.9	52.6	51.9	51.6	51.6	51.6	51.4	51.4	51.1	50.7	50.5	50.4	50.1	49.5	48.7	48.0	47.1	46.4
	RES	95.9	96.8	97.5	96.7	97.1	97.7	98.6	99.4	100	102	103	103	104	106	107	108	109	111	112	112	113
NC	COM	168	171	173	175	178	181	185	188	191	195	198	201	205	208	212	216	220	224	227	231	235
	IND	93.4	96.1	98.9	101.1	100.8	99.8	99.6	100	101	101	101	101	101	101	101	101	101	99.6	98.6	97.4	96.5
	RES	186	188	190	190	191	193	196	198	201	204	207	210	213	217	221	225	228	232	235	238	240
SC	COM	76.8	77.7	78.2	78.8	79.7	80.8	81.8	82.7	83.7	84.6	85.5	86.3	87.3	88.4	89.3	90.4	91.4	92.4	93.2	94.0	94.8
	IND	96.2	98.5	101	103	102	100	99.5	99.4	99.2	98.7	98.5	97.8	97.0	96.6	96.1	95.4	94.3	92.7	91.2	89.4	88.0
	RES	97.5	98.2	98.8	97.9	98.2	98.6	99.4	100	101	102	103	103	104	106	107	108	109	110	111	111	111
VA	COM	167	169	171	173	175	178	181	183	186	188	191	193	196	199	202	205	208	211	213	216	218
	IND	59.2	60.8	62.4	63.6	63.3	62.5	62.2	62.3	62.4	62.2	62.3	62.0	61.7	61.6	61.5	61.2	60.7	59.8	59.1	58.1	57.4
	RES	151	152	153	152	153	154	156	157	159	161	163	164	167	169	171	174	176	178	180	181	182
WV	COM	27.7	28.0	28.3	28.6	29.1	29.6	30.1	30.6	31.2	31.7	32.2	32.8	33.4	34.1	34.7	35.5	36.2	36.9	37.5	38.2	38.9
	IND	36.7	37.6	38.7	39.5	39.3	38.9	38.8	38.9	39.1	39.2	39.3	39.3	39.3	39.4	39.6	39.6	39.5	39.2	38.9	38.5	38.2
	RES	38.2	38.6	38.9	38.7	38.9	39.3	39.8	40.3	40.9	41.6	42.2	42.7	43.4	44.2	45.2	46.0	46.9	47.7	48.5	49.0	49.7

Table G.10 Baseline Values for Electricity Related Losses by Southern State and Sector, 2010-2030 (TBtu)																								
State	**Sector**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
DC	COM	67.5	64.8	67.5	67.1	66.3	65.7	65.2	65.0	64.6	64.2	63.7	63.3	62.8	62.3	61.9	61.5	61.1	60.8	60.5	60.1	59.6	59.2	58.9
	IND	1.73	1.58	1.55	1.56	1.57	1.57	1.53	1.48	1.44	1.42	1.39	1.36	1.33	1.30	1.26	1.24	1.21	1.18	1.15	1.11	1.07	1.04	1.00
	RES	13.1	12.8	12.7	12.6	12.4	12.1	11.9	11.7	11.6	11.5	11.4	11.3	11.2	11.0	11.0	10.9	10.8	10.7	10.7	10.6	10.5	10.4	10.2
DE	COM	32.6	31.9	33.9	34.3	34.6	34.8	35.3	35.8	36.3	36.7	37.1	37.5	37.8	38.2	38.6	39.0	39.4	39.8	40.2	40.5	40.8	41.1	41.3
	IND	23.1	21.6	21.6	22.1	22.7	23.1	22.9	22.6	22.4	22.4	22.4	22.2	22.2	22.0	21.8	21.7	21.5	21.4	21.1	20.7	20.3	19.9	19.5
	RES	32.6	32.4	32.8	33.1	33.3	33.0	33.1	33.3	33.6	33.8	34.1	34.5	34.7	34.9	35.2	35.5	35.9	36.2	36.5	36.7	37.0	37.0	37.1
FL	COM	716	706	756	772	785	800	818	838	859	879	900	921	942	964	988	1014	1039	1066	1094	1121	1147	1173	1200
	IND	142	133	135	139	144	148	148	148	148	150	152	153	154	155	156	158	159	160	161	160	160	159	158
	RES	875	877	894	910	925	927	939	954	973	991	1013	1036	1058	1077	1102	1129	1159	1186	1215	1243	1270	1292	1316
GA	COM	350	343	366	372	376	380	386	393	400	406	412	418	424	430	437	444	451	458	465	471	477	483	489
	IND	250	234	234	241	248	253	252	249	249	249	250	250	250	249	248	248	248	247	245	242	239	235	232
	RES	397	396	401	406	411	409	411	415	420	424	430	436	442	446	452	458	466	472	478	484	490	493	497
MD	COM	170	166	176	178	180	181	183	186	189	191	194	196	199	201	203	206	209	211	214	216	219	221	223
	IND	115	107	107	109	112	114	114	112	111	111	111	111	111	110	109	109	109	108	107	105	104	102	100
	RES	206	205	207	209	210	209	210	211	213	215	217	220	222	223	226	228	231	234	236	239	241	242	243
NC	COM	347	341	363	369	373	378	384	392	399	406	413	420	427	434	442	450	458	467	475	483	491	499	507
	IND	215	201	202	207	214	218	218	215	215	216	217	217	218	218	218	218	218	218	217	215	213	210	208
	RES	397	396	402	407	411	410	413	417	422	428	434	441	448	453	460	468	477	485	493	501	508	513	519
SC	COM	160	156	166	168	169	170	172	174	177	179	181	183	185	186	188	191	193	195	197	199	201	203	205
	IND	223	208	208	213	218	221	220	216	215	215	214	213	213	211	209	208	207	206	204	200	197	193	190
	RES	210	209	210	212	213	211	212	213	215	216	218	220	222	223	225	228	231	233	235	237	239	240	241
VA	COM	347	339	361	366	369	373	378	384	390	395	401	407	412	417	423	430	436	442	449	455	460	466	472
	IND	137	128	128	131	135	137	137	135	134	134	135	134	134	134	133	133	133	132	131	129	127	126	124
	RES	323	321	325	328	331	329	331	333	336	340	344	348	352	355	360	365	370	375	380	384	388	391	394
WV	COM	57.5	56.2	59.7	60.5	61.1	61.8	62.8	63.9	65.1	66.1	67.3	68.4	69.6	70.8	72.1	73.6	75.0	76.5	78.1	79.6	81.0	82.5	83.9
	IND	84.8	79.1	79.1	81.2	83.5	85.2	84.8	83.9	83.7	84.1	84.4	84.5	84.9	84.9	84.8	85.1	85.4	85.5	85.3	84.6	83.9	83.1	82.4
	RES	82.0	81.5	82.4	83.2	84.0	83.5	84.1	84.8	85.9	87.0	88.3	89.7	91.1	92.2	93.8	95.5	97.5	99.3	101	103	105	106	107

Table G.11 Baseline Projections for Natural Gas Consumption by Southern State and Sector, 2010-2030 (TBtu)																								
State	**Sector**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
DC	COM	17.0	16.8	17.3	16.9	16.5	16.3	16.0	15.8	15.6	15.3	15.1	14.8	14.5	14.2	14.0	13.8	13.6	13.5	13.3	13.1	12.8	12.6	12.4
DC	IND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC	RES	12.6	12.7	12.9	12.3	12.2	12.0	11.9	11.7	11.6	11.4	11.3	11.1	10.9	10.7	10.5	10.3	10.2	10.0	9.81	9.61	9.43	9.20	9.01
DE	COM	8.67	8.73	9.17	9.09	9.06	9.08	9.13	9.18	9.20	9.22	9.23	9.23	9.20	9.19	9.21	9.23	9.25	9.28	9.29	9.27	9.25	9.22	9.20
DE	IND	16.0	14.9	14.7	14.9	15.1	15.3	15.1	14.8	14.6	14.5	14.3	14.1	14.0	14.0	14.0	13.9	13.9	14.3	14.0	13.7	13.4	13.3	13.0
FL	IND	69.7	65.1	64.8	66.3	67.9	69.4	69.3	68.8	68.6	68.9	68.8	68.8	69.0	70.1	70.8	71.8	72.9	76.1	75.7	75.0	74.5	75.0	74.5
GA	IND	161	150	148	151	154	156	155	152	151	150	149	148	147	148	148	148	149	154	152	149	146	146	143
DE	RES	10.1	10.4	10.7	10.5	10.5	10.6	10.6	10.7	10.8	10.8	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.8	10.8	10.7	10.7	10.6	10.5
FL	COM	59.1	60.0	63.5	63.6	63.9	64.7	65.7	66.8	67.7	68.7	69.6	70.4	71.2	72.1	73.2	74.5	75.8	77.3	78.6	79.7	80.8	81.8	83.0
FL	RES	16.7	17.3	18.0	17.7	18.0	18.2	18.5	18.9	19.3	19.5	19.8	20.1	20.4	20.6	20.9	21.2	21.6	21.9	22.1	22.4	22.6	22.7	22.9
GA	COM	54.5	55.1	58.0	57.7	57.7	58.0	58.6	59.1	59.5	59.8	60.1	60.3	60.4	60.7	61.1	61.5	61.9	62.5	62.9	63.2	63.4	63.5	63.7
MD	IND	23.5	21.8	21.5	21.8	22.1	22.4	22.2	21.8	21.5	21.4	21.1	20.9	20.7	20.8	20.7	20.8	20.8	21.5	21.1	20.6	20.2	20.1	19.7
GA	RES	123	127	131	129	130	131	132	134	135	136	137	138	139	139	140	140	141	142	142	142	142	141	141
MD	COM	70.1	70.6	74.1	73.5	73.2	73.5	73.9	74.4	74.7	74.9	75.1	75.2	75.1	75.2	75.5	75.9	76.2	76.7	77.0	77.1	77.1	77.1	77.2
NC	IND	89.5	83.3	82.4	84.0	85.5	86.9	86.2	85.1	84.4	84.2	83.5	83.0	82.7	83.5	83.7	84.3	85.0	88.1	87.0	85.6	84.4	84.4	83.2
MD	RES	82.2	84.3	87.1	85.0	85.5	85.9	86.6	87.3	88.2	88.5	88.8	89.1	89.5	89.4	89.6	89.8	90.1	90.1	90.0	89.8	89.7	88.9	88.6
NC	COM	49.1	49.6	52.2	52.0	52.0	52.4	52.9	53.4	53.9	54.3	54.6	55.0	55.2	55.5	56.0	56.6	57.1	57.8	58.4	58.8	59.2	59.5	59.9
SC	IND	75.6	70.0	68.9	69.9	70.8	71.5	70.7	69.4	68.4	67.8	66.9	66.1	65.4	65.6	65.4	65.4	65.5	67.5	66.2	64.7	63.3	62.9	61.6
NC	RES	62.7	64.5	66.9	65.5	66.1	66.7	67.5	68.3	69.3	69.8	70.4	71.0	71.6	71.9	72.4	73.0	73.7	74.0	74.4	74.6	74.9	74.8	74.8
SC	COM	22.1	22.2	23.3	23.1	22.9	23.0	23.1	23.2	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.4	23.5	23.6	23.7	23.7	23.7	23.6	23.6
SC	RES	27.4	28.1	29.0	28.3	28.4	28.5	28.7	28.9	29.1	29.2	29.2	29.3	29.4	29.3	29.3	29.4	29.4	29.4	29.3	29.2	29.2	28.9	28.7
VA	COM	66.8	67.4	70.8	70.3	70.1	70.4	70.9	71.4	71.8	72.1	72.4	72.6	72.6	72.8	73.2	73.7	74.2	74.8	75.2	75.5	75.7	75.8	76.1
VA	IND	76.1	70.6	69.7	70.9	72.0	72.9	72.2	71.1	70.2	69.9	69.1	68.4	68.0	68.4	68.3	68.6	68.9	71.1	70.0	68.6	67.4	67.2	66.0
VA	RES	81.3	83.5	86.3	84.3	84.9	85.3	86.1	87.0	87.9	88.4	88.8	89.2	89.7	89.8	90.1	90.5	91.0	91.1	91.2	91.2	91.2	90.7	90.5
WV	COM	27.7	27.9	29.3	29.1	29.0	29.2	29.4	29.7	29.9	30.1	30.3	30.5	30.6	30.9	31.2	31.5	31.9	32.3	32.7	33.0	33.3	33.5	33.8
WV	IND	46.5	43.1	42.5	43.2	43.9	44.5	44.2	43.6	43.2	43.0	42.7	42.4	42.3	42.7	42.9	43.3	43.7	45.4	44.9	44.2	43.7	43.8	43.3
WV	RES	31.6	32.4	33.5	32.7	33.0	33.2	33.5	33.9	34.4	34.7	34.9	35.2	35.6	35.7	36.0	36.3	36.7	37.0	37.2	37.4	37.7	37.6	37.8